RELATIONSHIPS BETWEEN THE SURFACE LOW-PRESSURE SYSTEM'S DISPLACEMENT AND THE 500-mb SD AND SL BETA DECOMPOSITION PATTERNS

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ABSTRACT

The Fleet Numerical Weather Facility (FNWF), located at Monterey, California, has been producing 500-mb SD and SL analyses and forecast fields in their latest modified form since December 1964. These fields, designated as Beta Decomposition Patterns by FNWF, are elementary fields derived from the 500-mb pressure-height field, the SD-field being that of short-wave disturbances and the SL-field of long-wave disturbances.

An investigation of these fields, both SD-analyses and forecasts and SL-analyses was undertaken in association with the National Meteorological Center's surface pressure analyses to determine possible relationships that may exist between the displacement of the surface low-pressure system and the 500-mb SD low-pressure centers and also the direction of the surface system's displacements with the 500 SL-analyses. In addition, the accuracy of the FNFW 500-mb SD prognostic fields in predicting the 500-mb SD low-pressure center's position was determined. 21 cases were investigated using analyses of January, February and March 1965.

The purpose of this investigation was to relate the 500-mb analyses and prognoses to the displacement of surface cyclones.

The writer accomplished this investigation at the United States Naval Postgraduate School, Monterey, California.

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1. Introduction.

For quite some time, FNFW has been producing 500-mb SD and SL fields, however the program was modified in December 1964 and only the data since that time has been utilized for this study.

The procedure for obtaining the so-called SD and SL fields may be described briefly as follows. A smoothing operator (see eqn. 4) is applied a prescribed number of times resulting in the SR field. Then the difference

$$D - SR = SD \tag{1}$$

is formed. The SD field, so defined, is called the short-wave disturbance field. Further smoothing of the remaining SR field yields essentially the polar vortex, referred to as the SV field. Again forming a difference

$$SL = SR - SV \tag{2}$$

yields the long-wave disturbance field, SL. Combining equations (1) and (2) gives

$$D = SD + SL + SV \tag{3}$$

which shows that the procedure yields a representation of the 500-mb pressure-height field as a sum of the more elementary fields, called the Beta Decomposition Patterns. The smoothing operator referred to above, as applied to the D-field, may be expressed in the form

$$D_{N+1} = D_N + K_N \nabla^2 D_N \tag{4}$$

where K_N is a monotonic increasing function ranging from .0001 to about .125, and D is the initial 500-mb D-field.

It is the objective of this paper to examine these 500-mb decomposition patterns and determine the relationships that exist between the displacement of the surface low-pressure systems in the United States and the 500-mb SD low-pressure centers, both analyses and forecasts, and also the 500-mb SL-analyses. In addition, the accuracy and usefulness of the 500-mb prognostic fields will be investigated. The surface pressure maps were obtained from the National Meteorological Center.

Each complete system will be tabulated and an associated chart will give a pictorial presentation of each of the analyses.

2. Prodedure

For each low-pressure system, two tables were compiled, the first giving the displacement of the surface low-pressure center and that of the 500-mb SD low-pressure center for 12, 24, 36, and 48 hours. In addition, the 48-hour predicted displacements were shown. It was originally intended to show both the 24-hour and 48-hour predicted displacements, but except for a few cases, the 24-hour prognostic maps were unavailable. The second table contained the central pressure of the surface low-pressure system, the bearing and distance of the 500-mb SD predicted low centers from the 500-mb SL analysis with the direction and speed of the indicated flow over the surface low-pressure center.

In addition, a map was plotted for each system indicating the 12-hour positions for each of the different low centers and their displace-

placements. Pertinent SL-analysis features were placed on these maps.

3. Results.

A. General.

21 separate systems were analyzed from January 1965 through March 1965. 19 of these cases can be divided into three primary classifications, Midwestern United States with basic southwest to northeast movement, Eastern United States with basic southwest to northeast movement, and those systems moving west to east along the northern part of the United States and into Canada. The other two types occured along the Pacific Coast, one being primarily stationary and the other in the Rocky Mountains. There were five systems in the Midwest, six along the East Coast, and eight in the northern United States. Within these classifications, there was a further breakdown. The factors considered in allowing these subclassifications were the speeds of movement of the surface low-pressure systems, the place of origin of the surface low-pressure systems, and the initial direction of movement of the surface low-pressure system.

B. Midwestern Systems:

The midwestern low-pressure systems can be divided into two classifications, those who speeds of the surface low pressure system was greater than 30 knots and those less than 30 knots, after averaging the total available analyses. There were two of the first classification and three of the second. It must be noted that except for this difference in

speed of movement, their other characteristics were very similar, such as direction of movement, related SL-analyses, and the deepening of the surface low as it proceeded northward.

First, the two faster moving systems will be discussed, figures 1 and 2. The displacement of both the 500-mb SD low center and the surface low center agree within a few degrees and a few knots of each other after 24, 36, and 48 hours. The bearing and distance of the 500-mb center from the surface low for both systems began almost to the west and shifted southwestward as the systems moved more to the northeast. As they moved northeastward, the distance between them decreased almost equally for both systems and the bearings from each other were quite similar. The 48-hour prognostic low centers of the 500-mb SD field showed this northeastward displacement also, but they were such a great distance from the analyzed SD low centers, that one could consider them virtually worthless. The SL patterns indicate troughs well behind the surface low centers but the flow pattern show a very close relationship to the direction of movement of the surface low centers for the succeeding 12 hours.

Secondly, the remaining three midwestern type systems were investigated, figures 3, 4, and 5. The basic pattern was observed to be fairly similar to the other types, however due to the slower speeds of movement, the final orientation of the 500-mb SD analyzed low center is more southwesterly from the surface low center. The displacement of

the surface lows and 500-mb SD analyzed low centers in cases 3 and 4 were similar for 80% of the time for 24, 36, and 48-hour movements. The bearings and distances of the 500-mb low center from the surface low was once again westward at quite a large distance, but as the systems move northeastward, the two centers became orientated more southwesterly from each other and the distance between them decreased. In case 5, there was a slight variation in a small portion of the 500-mb SD pattern, but as time progressed, the pattern became similar to those of cases 3 and 4. Once again, the 48-hour 500-mb SD prognostic position of low centers showed a marked disagreement with the analyzed 500-mb SD low centers except in two cases. In case 5, the 24-hour 500-mb SD prognostic fields were available, but the low centers correlated very poorly with the analyzed SD low centers. The 500-mb SL analyses once again showed troughing well behind the surface low-pressure centers. The flow indicated on the SL analyses once again gave a good indication of the movement of the surface low center for the succeeding 12 hours.

C. Canadian - US Border Systems.

The Canadian-US Border Systems can be broadly divided into two classification, those systems originating in the Pacific and moving northeastward until they reach into Canada from whence they proceed in an eastward direction, and those which originated in Canada and swung through a big arc in the northern United States. In this latter classification, there are a few differences among the systems in the grouping.

There were two cases investigated in the first classification and six cases in the second. Similar characteristics throughout the whole eight cases were that of the close adherence to the SL analysis flow and the primary west to east movement. In just about all of the cases, there were small changes in the surface pressure, but there was no consistant pattern. The pressures rise and fall a few millibars every 12 hours but basically remained between 1005 and 990 mbs and each case had little variations within itself.

Looking at the two cases of the systems moving in from the Pacific, figures 6 and 7, there was one discrepency in both cases. When the 500-mb SD low center came over the Pacific Coast, the next 12-hour position was displaced to the north, throwing a disconinuity in the analyses, however in subsequent maps, the 500-mb SD low returned to a position similar to those of other analyses. In over 70% of the cases, the 24, 36, and 48-hour displacements of both the 500-mb SD low center and the surface low center agreed within a few degrees and a few knots of each other. The bearing of the 500-mb SD low center from the surface low center was at first to the west. As the surface center proceeded northeastward to the Pacific Coast, the bearing became more to the southwest but once the surface center moved in an eastward direction, the 500-mb SD low center was once again found westward from the surface center. The distance between the two centers varied approximately the same in both cases. The 48-hour SD prognoses showed definite patterns

in both cases, but with the exception of one chart there was very little relationship between these plotted positions and those of the 500-mb analyzed SD low centers. The 500-mb SL analyses showed troughing behind the surface lows in some cases but the basic flow pattern gave further confirmation to the fact that the surface low centers move in the approximate direction of SL flow.

The second classification, those systems coming out of Canada, gave us six cases, figures 8, 9, 10, 11, 12, and 13. Excluding case 13 for a moment, the first five cases can be considered to be extremely similar. The primary direction of movement of the surface low centers and that of the 500-mb SD low centers after 24, 36, and 48 hours of analyzed movement lay mainly between 085 and 105 degrees. The speed of movement over these periods varied between 25 and 35 knots. The initial bearing of the 500-mb SD low center from the surface low center was a little north of west and as the systems moved across the country to the east, the bearing became westerly then southwesterly. In the great majority of the cases, the distance between the two centers decreased for each succeeding 12-hour analysis from over 450 miles to less than 200 miles. From the 500-mb 48-hour SD prognosis, we received indications of low centers in the general region. However, the distances from the analyzed centers were so erratic that these prognoses were virtually worthless for prediction purposes. The 500-mb SL analysis showed definite troughs and the flow over the surface low center gave an

extremely good approximation to the future direction of movement and in a majority of the cases, the gradient gave an indication of the speed with which the surface low center moved in the succeeding 12 hours.

Case 13, although eventually becoming a system with west to east flow, exhibited different properties in some instances than the other five cases in this classification. The system was much faster moving and originated much further north in Canada with a marked southeasterly direction of movement of both the surface low center and the 500-mb low center. The main difference in this case was that the 500-mb low center remained to the north of the surface low center, although their associated displacements were similar to a certain degree. The 24-hour 500-mb prognostic field of the SD pattern showed very good agreement with the analyzed SD centers in the last 36 hours. Once again, the 48-hour prognosis of the SD low centers showed almost no agreement with the analyzed centers. The flow indicated by the 500-mb SL analysis at the position of the surface low center gave a good approximation to the future movement of the surface low-pressure center.

D. East Coast Systems:

The East Coast Systems can be divided into three classifications, those originating in the Gulf of Mexico and moving rapidly to the northeast, those originating in the southern states and moving rapidly to the northeast, and those originating near the southeastern coast of the United States and moving first east then northeast. There were two cases in-

vestigated for each one of the above mentioned classifications. In general, the SL analyses gave good correlation to the direction of movement of the surface systems and in half of the six cases, the prognostic charts gave no indication whatsoever. Each of the systems showed a deepening of the surface low centers as they proceeded northeastward. Once the center became located over the ocean, there was a deepening of at least eight millibars in each succeeding 12-hour period in five of the six cases.

The first classification, those with surface low-pressure centers originating in the Gulf of Mexico, figures 14 and 15, moved rapidly northeastward in a relatively straight path. In both cases, the speeds of movement of both the surface low and the 500-mb SD low were greater than 36 knots for all the 12, 24, and 36-hour movements and actually favored the low 40 knot speeds. Due to this extremely rapid movement, 36 hour tracks were all that could be investigated. The bearing of the 500-mb SD low center from the surface low center was consistantly to the northwest in every 12-hourly position and the distance between the two centers in both cases showed a constancy of approximately 100 miles. For the majority of the 24 and 36 hour time periods, the displacements of both the surface low and the 500-mb SD low were similar. The 500-mb SL analysis showed very strong northeasterly flow in both cases, further substantiating the concept that the future movement of the surface low-pressure center is closely associated with

this indicated flow.

The second classification, those surface low centers originating in the Southern States and which moved rapidly to the northeast, figures 16 and 17, showed a good degree of similarity. Once again, due to the speed of movement of these systems, 36-hour displacement was the extent that these systems could be investigated. With the exception of one 500-mb SD low center, the displacements of both systems were alike. The bearing of the 500-mb SD low center was more westerly in these cases and the distance between the two centers in the two cases remained relatively constant. In each separate case, the relationship of the displacement of the surface low and the 500-mb SD low was almost identical for 24 and 36-hour periods over 80% of the time. The 48-hour 500-mb SD prognosis gave no indication in either case of any low centers, however in one instance, the final 24-hour SD prognosis indicated a low center within 80 miles of the analyzed SD low center. This was after the system had been moving for 36 hours. The 500-mb SL analysis indicated troughing in one case, but in both cases, the surface low center movement paralleled the flow indicated by the SL analysis.

The third classification of the cases in this East Coast System were those which originated on the southeastern coast of the United States and moved in an easterly direction before turning northeastward, figures 18 and 19. Each case is different in regard to their displacement, but

move in generally the same sense. The slower moving system had excellent consistancy between the surface low center's displacement and that of the 500-mb SD low center for the 24, 36, and 48-hour movements. The other case, that of the faster system, showed very good comparison as far as speed was concerned. The bearing of the 500-mb SD low center from the surface low was predominantly to the southwest with the distance between them averaging about 300 miles. The 48-hour 500-mb SD prognosis gave indications of low centers in both investigations, but only one position could be reasonably considered to be useful out of the nine 12-hour maps investigated. The 500-mb SL analysis showed definite trough patterns. The flow pattern depicted on these charts over the surface low center gave a close approximation to the succeeding 12-hour movement of that center.

E. Pacific Coast Systems.

The remaining two cases were both different from each other except for two results. The 48-hour 500-mb SD prognosis gave only one reasonable indication of the 500-mb SD low center in 14 observations so it can be considered virtually worthless. The other similarity was that the 500-mb SL analysis gave approximations to the future movement of the surface low center. The first case, figure 20, showed a system moving down from Canada. The bearing of the SD low center from the surface low center was basically west and the distance between them depended upon the position of the system in latitude and longitude.

This was due to the fact that the Rocky Mountains forced the surface low center to the east. The displacement after 24, 36, and 48 hours of both the 500-mb SD low and the surface low agreed in over 80% of the observations. The second case, figure 21, showed a stationary low system off the Pacific Coast. There was little consistancy between the 500-mb SD low centers and the surface low centers in relation to bearings from each other, but the distance between them usually remained less than 200 miles. However, both systems moved at slow speeds and in the later stages, the same direction.

4. Conclusions.

After almost three months of data, it appears that there are three primary low-pressure tracks across the United States, one up the East Coast, one up through the Midwest, and one along the Canadian-United States Border during the winter months. The low centers on the 500-mb SD analysis shows remarkable correlation with the surface low-pressure centers. It appears that once a pattern of two or three SD low centers and surface low centers has been located, one can project the SD centers ahead 12 to 48 hours utilizing the tables in the appendix, which give the bearing and distance of the 500-mb low center from the surface low center and the average displacement of both. The position of the surface low center can then be placed in a fairly accurate position. The basic errors incorporated in this system stems primarily from two factors. The first is the rather large grid scale of the 500-mb SD

analysis which can give a difference of the center of the low in tens of miles. The second is that the subjective analysis results in considerable variation in the position of the surface low-pressure center.

One of the more pleasing conclusions is the usefulness of the 500-mb SL analysis. In just about every analysis, the movement of the system very nearly paralleled the flow indicated by the SL analysis. In 83 12-hour maps investigated, the direction of movement of the surface low-pressure center was within 10 degrees of the indicated SL flow over 71% of the time for the succeeding 12 hours. The geostrophic wind was scaled from the SL analysis but did not in general compare as favorably with the speed of movement of surface systems. However, the gradient was indicative of the speed of movement of the faster moving systems. This SL analysis therefore gives an excellent aid to the forecaster for predicting the displacement of the low-pressure centers.

The 48-hour 500-mb SD prognostic charts proved least useful in predicting the location of the SD low centers. In almost every instance, the predicted position of the center was in complete disagreement with the analysed position. For some systems, there was no indication of any low center on the prognosis.

The 24-hour 500-mb prognoses proved reasonably accurate in 50% of the cases. However, due to the unavailability of the maps, a sufficient sample was unavailable.

In summary, the 500-mb SL analysis proved very useful in predicting the direction of movement of the surface low centers, the 48-hour SD prognosis proved useless, and a very close relationship was seen to exist between the 500-mb SD low centers and the surface low centers.

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COMPARISON OF AVERAGE SURFACE LOW CENTER DISPLACEMENT WITH 500-mb SD LOW CENTER DISPLACEMENTS

SYSTEMS	# OF SAM-PLES	AVG SFC DISPLACE-MENT	AVG SD DISPLACE-MENT	DIFFERENCE (SFC TO LEFT (+))
MIDWEST FAST				
24-hour	5	042/36	046/39	004/-03
36-hour	3	044/35	046/39	002/-04
MIDWEST SLOW				
24-hour	11	046/27	054/26	008/01
36-hour	8	047/27	054/27	007/00
48-hour	5	048/26	054/25	006/01
PACIFIC-CANADA				
24-hour	9	074/29	064/27	-010/02
36-hour	7	068/29	062/27	-006/02
48-hour	5	069/29	063/28	-006/01
CANADA-U.S. BORDER				
24-hour	26	099/29	105/29	006/00
36-hour	20	099/28	106/28	007/00
48-hour	14	098/28	105/28	007/00
EAST COAST				
24-hour	13	064/38	066/37	002/01
36-hour	7	065/36	066/36	001/00
48-hour	1	075/22	076/22	001/00

APPENDIX I

TABLES OF COMPARISONS

MIDWEST (SW-NE) Fig. 1							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
09 Feb/1200	1005	253/370		265/840		272/520	Tr behind low 020/38
10/0000	997	240/200		255/780		260/600	Tr Stat. 034/38
10/1200	991	235/140		243/700		247/570	Tr Stat. 054/40
11/0000	990	241/130		270/810		275/700	Tr Stat. 060/35

Tr - Trough

Stat - Stationary

MIDWEST (SW-NE) Fig. 1

DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
09 FEB/ 1200/05										
10/0000/97	020/30				042/35					
10/1200/91	035/35	028/32			035/37	038/37				047/27 (24)
11/0000/90	055/40	047/37			055/42	046/39	043/38			032/33 (36)

MIDWEST (SW-NE) Fig. 2							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
11 FEB/1200	1006	263/430		299/600		342/360	Tr on low 019/30
12/0000	1001	247/380		295/480		334/330	Tr moving East 038/40
12/1200	990	244/230		293/370		331/280	Tr moving East 058/42
13/0000	990	242/150		270/570		275/450	Tr moving East 041/40
13/1200	989	242/210		249/810		255/620	Tr Stat. 027/45

MIDWEST (SW-NE) Fig. 2										
DATE TIME PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
11 FEB/ 1200/06										
12/0000/01	042/40				057/47					
12/1200/90	078/32	039/36			037/37	045/41				050/35 (24)
13/0000/90	060/41	047/36	049/37		061/48	052/41	050/42			052/28 (30)
13/1200/89	040/37	051/38	044/36	045/36	036/33	051/33	046/38	048/38		046/23

MIDWEST (SW-NE) Fig. 3							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
24 FEB/1200	1001	280/430		325/680		360/480	Tr behind 053/30
25/0000	990	248/270		330/640		350/600	Tr moves east 045/34
25/1200	979	231/240		286/430		318/390	Tr moves east 043/33
26/0000	967	229/100		275/440		285/380	Tr moves east 000/28
26/1200	976	229/160		243/410		249/270	Tr moves east 345/40

MIDWEST (SW-NE) Fig 3										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	38	24	48
24 FEB/ 1200/01										
25/0000/90	039/32				073/35					
25/1200/79	035/32	037/31			047/30	059/31				067/18(24)
26/0000/67	049/29	042/30	043/30		048/40	050/34	056/33			063/18(36)
26/1200/76	028/26	040/26	038/28	040/29	021/21	040/29	051/29			067/18

MIDWEST (SW-NE) Fig. 4							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
26 JAN/0000	993	262/230					Well Def Tr behind 062/45
26/1200	988	228/240					Tr moving East 065/40
27/0000	984	216/270					Continued East mov. 050/40
27/1200	984	208/180					Continued East mov. 040/30
28/0000	988	215/240					Continued East mov. 350/25

MIDWEST (SW-NE) Fig. 4										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
26 JAN/ 0000/93										
26/1200/88	054/40				071/38					
27/0000/84	059/33	057/37			064/38	067/38				
27/1200/84	042/27	052/29	052/32		042/27	056/32	059/33			
28/0000/88	041/21	041/23	049/26	050/29	036/16	040/21	053/27	055/29		

MIDWEST (SW-NE) Fig. 5							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
16 MAR/1200	998	273/470		275/580		272/115	Tr behind 058/30
17/0000	990	218/180		251/670		264/540	Tr moves East 077/35
17/1200	989	225/60	257/300	256/630	260/260	260/600	Tr moves East 058/35
18/0000	988	265/360	265/640	272/720	268/280	279/360	Tr moves East 052/30
18/1200	987	250/210	254/540	276/420	259/340	297/280	Stationary 032/45
19/0000	990	216/290	135/180	217/245	071/320	025/50	Tr moving East 029/35
19/1200	994	206/440	207/160	212/420	027/280	307/40	Tr moving East 000/32

MIDWEST (SW-NE) Fig. 5										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
16 MAR/ 1200/98										
17/0000/90	028/27				075/42					
17/1200/89	071/30	049/27			059/40	067/38				061/20(24)
18/0000/88	056/27	061/28	053/27		340/15	038/23	055/27			044/31(36)
18/1200/87	044/23	050/24	058/26	052/26	065/32	041/19	053/25	059/28	029/15	054/27
19/0000/90	031/18	038/19	047/21	053/24	083/12	068/21	049/16	053/23	074/45	063/32
19/1200/94	038/30	036/23	040/23	046/23	089/21	066/16	067/21	055/17	061/37	063/27

PACIFIC-CANADA (W-E) Fig. 6							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
26 FEB/1200	1002	279/190		344/450		005/410	Tr behind 068/25
27/0000	992	242/320		354/500		009/690	Tr behind 062/25
27/1200	986	224/180		285/280		315/240	Tr behind 095/35
28/0000	988	267/480		286/550		328/100	Tr Disappeared 100/25
28/1200	999	260/360		279/640		295/320	No Tr 090/17

PACIFIC-CANADA (W-E) Fig. 6

DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
26 FEB/ 1200/02										
27/0000/92	068/35				123/24					
27/1200/86	055/22	061/23			055/33	077/23				112/14(24)
28/0000/83	082/37	072/30	068/28		030/15	048/23	066/18			105/14(36)
28/1200/99	100/23	090/30	083/27	079/27	102/37	085/22	075/28	081/23		105/14
	DISAPPEARED INTO HIGH									

PACIFIC-CANADA (W-E) Fig. 7							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
04 FEB/1200	997	253/160		NO INDIC		NO INDIC	005/25 behind high
05/0000	992	259/350		252/230		270/120	035/25 behind high
05/1200	994	240/270		253/460		270/210	065/20
06/0000	992	269/250		288/700		297/500	Tr formed on SFC Low 105/35
06/1200	996	306/480		294/570		240/120	Tr on SFC Low 106/40
07/0000	999	282/450		290/720		301/280	Tr behind 092/32
07/1200	996	270/270		270/340		270/70	Tr behind 075/37
08/0000	989	260/340		259/700		259/260	Tr behind 062/44

PACIFIC-CANADA (W-E) Fig. 7

DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
04 FEB/ 1200/97										
05/0000/92	036/31				000/25					
05/1200/94	035/27	036/29			057/28	032/24				
06/0000/92	050/27	042/27	042/28		033/33	044/29	034/27			359/31(24)
06/1200/96	075/33	065/32	055/30	052/30	030/42	031/57	038/33	034/30		028/28(36)
07/0000/99	090/34	083/34	074/32	065/31	114/38	071/29	058/30	060/29		041/25
07/1200/96	063/23	077/26	077/28	070/29	083/22	104/27	012/27	064/28		065/29
08/0000/89	073/40	071/29	077/29	077/30	083/33	083/27	095/28	076/29		090/31

CANADA-U.S. BORDER (W-E) Fig. 8							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
13 MAR/1200	1015	266/310		233/400		180/240	Tr on Low 121/15
14/0000	1010	265/230		235/560		217/360	Tr Stat 125/24
14/1200	1005	264/140		240/270		220/160	111/30
15/0000	1005	264/130		275/330		282/190	101/45
15/1200	1005	265/130		275/170		309/50	093/42

CANADA-U.S. BORDER (W-E) Fig. 8

DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
13 MAR/ 1200/15										
14/0000/10	112/18				106/25					
14/1200/05	132/15	122/18			113/23	109/24				106/21(24)
15/0000/05	111/29	120/22	118/21		111/30	113/26	112/25			097/20(36)
15/1200/05	097/50	105/38	107/30	118/28	098/50	102/39	104/33	107/30		096/31

CANADA-U.S. BORDER (W-E) Fig. 9							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
19 FEB/1200	1000	298/450		242/500		180/480	096/40
20/0000	992	288/350		284/750		278/400	116/48
20/1200	978	308/380		NONE		NONE	120/45
21/0000	985	270/370		330/390		029/380	116/25
21/1200	994	255/340		324/340		018/390	Tr Stat. 105/19
22/0000	994	263/380		235/470		232/100	Tr moves East 090/22
22/1200	989	240/280		288/310		350/250	Tr Disappeared 340/15

CANADA-U.S. BORDER (W-E) Fig. 9										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
19 FEB/ 1200/00										
20/0000/92	099/52				109/56					
20/1200/78	102/44	102/48			090/43	102/48				NO INDIC
21/0000/85	065/29	090/32	093/37		116/19	097/30	103/38			
21/1200/94	102/18	085/20	092/33	097/33	116/25	118/21	106/29	105/35		
22/0000/94	108/21	105/19	090/21	095/26	103/18	109/20	113/20	102/26		162/25(24)
22/1200/89	090/15	099/17	100/18	090/19	102/27	102/22	109/23	110/22		126/17(36)

CANADA-U.S. BORDER (W-E) Fig. 10							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
15 FEB/0000	1005	290/280		315/480		344/250	St Tr on each end 094/30
15/1200	1008	289/320		287/530		275/200	Tr remain 087/40
16/0000	1011	275/300		291/530		311/260	Tr remain 090/45
16/1200	1008	270/200		322/330		000/280	Tr remain 090/40
17/000	1002	256/180		319/250		000/240	Tr remain 075/35

CANADA-U.S. BORDER (W-E) Fig. 10

DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
15 FEB/ 0000/05										
15/1200/08	086/23				084/20					
16/0000/11	083/25	084/24			099/27	092/23				
16/1200/08	081/28	083/27	083/26		085/36	091/30	090/27			076/38(24)
17/0000/02	076/37	077/33	077/30	079/28	081/37	082/36	087/32	089/29		080/34(36)

CANADA-U.S. BORDER (W-E) Fig. 11							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
30 JAN/1200	992	306/260		276/530		252/330	Ridge on SFC Low 085/20
31/0000	992	277/480		295/810		318/410	132/37
31/1200	992	296/300		305/1000		306/680	135/45
01/0000	996	287/260		309/780		319/540	Tr behind 120/45
01/1200	1000	276/250		270/450		261/210	Tr behind 090/45
02/0000	1001	226/210		224/520		222/210	Tr moving Eastward 082/35
02/1200	1002	230/300		000/000		050/300	Tr moving Eastward 060/45
03/0000	991	236/440		036/60		234/500	Tr moving Eastward 034/50

CANADA-U.S. BORDER (W-E) Fig. 11										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
30 JAN/ 1200/92										
31/0000/92	097/48				130/28					052/32(12)
31/1200/92	120/41	109/44			107/57	110/41				075/29(24)
01/0000/96	124/35	122/37	114/41		125/39	119/47	117/40			097/32(36)
01/1200/00	087/33	104/32	112/31	109/37	090/34	113/34	111/40	109/37		111/40(48)
02/0000/01	051/30	068/30	090/28	101/28	082/32	089/31	105/31	103/38		114/44
02/1200/02	100/30	074/28	080/30	092/28	106/28	094/32	092/31	107/29		100/32
03/0000/91	066/38	082/31	076/30	074/31	068/28	083/25	086/27	087/31		092/40

CANADA-U.S. BORDER (W-E) Fig. 12							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
09 MAR/0000	1005	312/170		000/300		032/220	Possible Tr forming 130/20
09/1200	1005	112/120		100/330		092/210	Tr behind 090/22
10/0000	1005	260/270		212/190		122/220	Tr Stat. 100/21
10/1200	1004	263/310		088/130		086/440	Poss New Tr 090/22
11/0000	1000	240/260		102/280		084/520	New Tr move east 075/25
11/1200	992	255/330		061/540		068/860	Tr move east 046/38
12/0000	982	231/200		242/380		257/200	Tr move east 030/45

CANADA-U.S. BORDER (W-E) Fig. 12

DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
9 MAR/ 0000/05										
09/1200/05	105/18				122/20					
10/0000/05	090/20	098/18			141/10	126/15				149/25(24)
10/1200/04	117/19	109/19	115/18		123/18	130/14	125/15			123/23(36)
11/0000/00	097/23	110/20	102/19	104/19	109/33	116/23	122/19	118/20		100/28
11/1200/92	098/36	100/29	104/25	102/23	090/26	101/29	105/25	108/21		082/30
12/0000/82	046/23	079/25	087/24	092/22	070/31	080/28	092/28	094/25		095/17

CANADA-U.S. BORDER (W-E) Fig. 13							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
21 MAR/0000	1019	007/280	109/390	083/530	142/530	128/370	180/50
21/1200	1013	042/170	138/310	011/370	170/250	355/360	157/45
22/0000	1011	340/250	021/80	299/260	145/210	233/190	Poss Tr behind 129/45
22/1200	1011	341/220	348/150	339/540	150/90	335/330	Tr backing 102/52
23/0000	1013	353/320	341/230	287/870	201/130	263/760	Tr Stat 097/50
23/1200	1011	346/340	349/340	324/470	243/60	270/180	092/43

CANADIAN-U.S. BORDER (W-E) Fig. 13										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
21 MAR/ 0000/19										
21/1200/13	124/35				136/47					
22/0000/11	135/33	129/34			155/17	144/31			143/18	180/21(24)
22/1200/11	110/26	123/29	126/31		115/27	131/20	135/30		096/15	127/10(36)
23/0000/13	102/45	103/35	118/32	120/33	090/43	100/34	112/25	124/29	096/33	158/12
23/1200/11	095/40	098/42	102/31	109/33	090/33	090/37	098/32	106/28	090/38	117/24

EAST COAST (FAST MOVING - SW-NE) Fig. 14										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
14 FEB/ 0000/04										
14/1200/10	046/44				066/42					
15/0000/08	056/52	050/47			078/36	073/38				
15/1200/00	068/45	062/48	056/47		064/48	069/42	069/41			060/22(24)

EAST COAST FAST MOVING (SW-NE) Fig. 14							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
14FEB/0000	1004	326/780		341/1080		007/360	Tr over SD Anal 028/43
14/1200	1010	325/560		285/1030		253/630	Tr Stat 051/48
15/0000	1008	297/400		270/1110		255/770	Tr backing 070/48
15/1200	1000	307/400		270/1400		255/1060	Stat 100/50

EAST COAST FAST MOVING (SW-NE) Fig. 15							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
20 MAR/0000	1013	289/550	NO INDICATIONS ON PROG. CHARTS				058/60
20/1200	1010	293/600	NO INDICATIONS ON PROG. CHARTS				056/50
21/0000	1000	299/660	NO INDICATIONS ON PROG. CHARTS				048/60
21/1200	998	312/510	NO INDICATIONS ON PROG. CHARTS				049/50

EAST COAST (SW-NE) FAST MOVING Fig. 15										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
20 MAR/ 0000/13									NO INDICATION	
20/1200/10	058/42				047/39				ON PROG	
21/0000/00	059/46	058/43			046/43	047/41			CHARTS	
21/1200/98	047/37	055/41	058/41		062/50	056/46	056/43			

EAST COST FAST MOVING (SW-NE) Fig. 16							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
10 JAN/0000	1015	279/350		NO INDIC		NO INDIC	Tr behind NE flow
10/1200	1010	283/270		NO INDIC		NO INDIC	Tr move East NE flow
11/0000	1009	289/370		NO INDIC		NO INDIC	Tr move East NE flow
11/1200	1008	303/380		NO INDIC		NO INDIC	Tr move East NE flow

EAST COAST (SW-NE) FAST MOVING Fig. 16										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
10 JAN/ 0000/15									NO INDICATION	
10/1200/10	061/27				067/32				NO INDICATION	
11/0000/09	080/42	073/34			067/37	066/34			NO INDICATION	
11/1200/08	059/46	069/44	069/38		052/48	060/43	061/38		NO INDICATION	

EAST COAST FAST MOVING (SW-NE) Fig. 17							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG		SL ANALYSIS REMARKS
			24	48	24	48	
26/0000	1006	255/490	NO INDICATION		NO INDICATION		048/50
26/1200	1010	270/500	NO INDICATION		NO INDICATION		072/43
27/0000	1002	290/690	NO INDICATION		NO INDICATION		080/44
27/1200	991	265/420	270/360	NO INDIC	032/80	NO INDIC	090/30

EAST COAST (SW-NE) FAST MOVING Fig. 17										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
26 MAR 0000/06									NO INDICATION	
26/1200/10	048/42				030/46				NO INDICATION	
27/0000/02	081/45	064/44			054/40	043/43			NO INDICATION	
27/1200/90	035/43	061/41	056/43		074/42	063/42	056/43		1st INDI	NONE

EAST COAST (SW-NE) Fig. 18							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
31 JAN/0000	1002	290/480		290/720		290/240	Tr behind 080/50
31/1200	994	284/390		274/870		266/500	Tr moves East 058/50
01/0000	980	250/250		264/840		270/600	Tr slows eastward 042/50
01/1200	966	224/230		237/740		244/520	Tr moves East 034/50

EAST COAST (SW-NE) Fig 18										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
31 JAN/ 0000/02										
31/1200/94	080/37				090/41					106/22(12)
01/0000/80	056/41	065/38			076/46	082/42				084/25(24)
01/1200/	040/42	046/40	055/38		050/41	065/41	072/39			086/32(36)

EAST COAST (SW-NE) Fig. 19							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
08 MAR/0000	1008	234/330		252/680		270/400	106/25
08/1200	1004	245/260		234/620		259/380	076/32
09/0000	992	243/170		256/580		262/430	055/40
09/1200	984	235/310		263/340		325/150	Tr moves east 056/40
10/0000	976	231/360		284/150		031/270	Tr moves east 050/40

EAST COAST (SW-NE) Fig. 19										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
08 MAR/ 0000/08										
08/1200/04	109/20				090/23					
09/0000/92	094/23	102/21			087/28	089/25				094/25(24)
09/1200/84	054/33	069/25	081/22		059/20	074/24	081/23			077/31(36)
10/0000/76	062/22	055/27	070/24	075/22	069/19	061/19	071/22	076/22		075/32

PACIFIC COASTAL (NW-SE) Fig. 20							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
08 FEB/1200	1000	238/320		274/720		293/540	Tr inland 131/40
09/0000	997	263/430		270/960		278/500	Tr Stat 145/40
09/1200	1001	257/500		277/900		299/600	Tr Stat 180/23
10/0000	998	274/510		264/600		203/120	Tr Stat 010/30
10/1200	1000	277/240		305/480		335/200	Tr Stat 090/12

PACIFIC COASTAL (NW-SE) Fig. 20										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL				500 SD PROG	
	12	24	36	48	12	24	36	48	24	48
08 FEB/ 1200/00										
09/0000/97	131/32				131/18					145/30(12)
09/1200/01	150/39	141/36			147/46	144/32				139/29(24)
10/0000/98	162/33	155/36	149/34		156/22	153/33	148/29			145/DIFF
10/1200/00	230/22	190/24	169/27	160/28	149/15	156/18	156/27	152/25		136/DIFF

PACIFIC COAST (STAT.) Fig. 21							
DATE/TIME	SURFACE PRESSURE	B/D OF SFC ANAL TO SD ANAL	B/D SFC ANAL TO SD PROG.		B/D SD ANAL TO SD PROG.		SL ANALYSIS REMARKS
			24	48	24	48	
03 MAR/1200	1011	207/310		210/570		214/270	Col Area ⊕ Flow
04/0000	1000	207/310		254/700		277/570	Col Area 305/12
04/1200	1002	180/180		247/570		266/520	Col Area 300/15
05/0000	996	153/290		218/330		270/340	Col Area 270/20
05/1200	1004	090/120		201/560		209/610	Col Area 260/20
06/0000	1008	070/160		178/440		198/500	Col Area 250/20
06/1200	1008	068/160		180/170		217/270	Col Area 260/20
07/0000	1010	059/170		346/180		294/200	Low Press Center Forming 240/20
07/1200	1015	000/90		304/490		294/420	Low center 270/20

PACIFIC COAST (STAT) Fig. 21										
DATE/ TIME/ PRESS	SURFACE ANAL				500 SD ANAL			500 SD PROG		
	12	24	36	48	12	24	36	48	24	48
03 MAR/ 1200/11										
04/0000/00	090/18				088/18					
04/1200/02	330/05	074/09			035/14	066/15				
05/0000/96	011/02	347/03	070/06		106/14	073/12	077/14			090/20(24)
05/1200/04	057/07	050/04	023/04	065/06	009/25	042/13	041/14	054/13		110/18(36)
06/0000/08	145/12	118/07	108/04	090/03	121/09	034/12	060/10	051/12		109/18
06/1200/08	146/08	146/09	125/07	120/05	129/08	125/08	051/08	073/08		094/15
07/0000/10	143/13	147/12	147/10	135/09	146/11	139/09	135/09	079/06		072/10
07/1200/15	101/20	117/17	123/13	129/12	119/10	134/10	134/09	131/09		030/
		SFC LOW DISAPPEARS								

Illustrations:

Interpretation of Symbols.

 Surface low-pressure center

 500-mb SD low-pressure centers

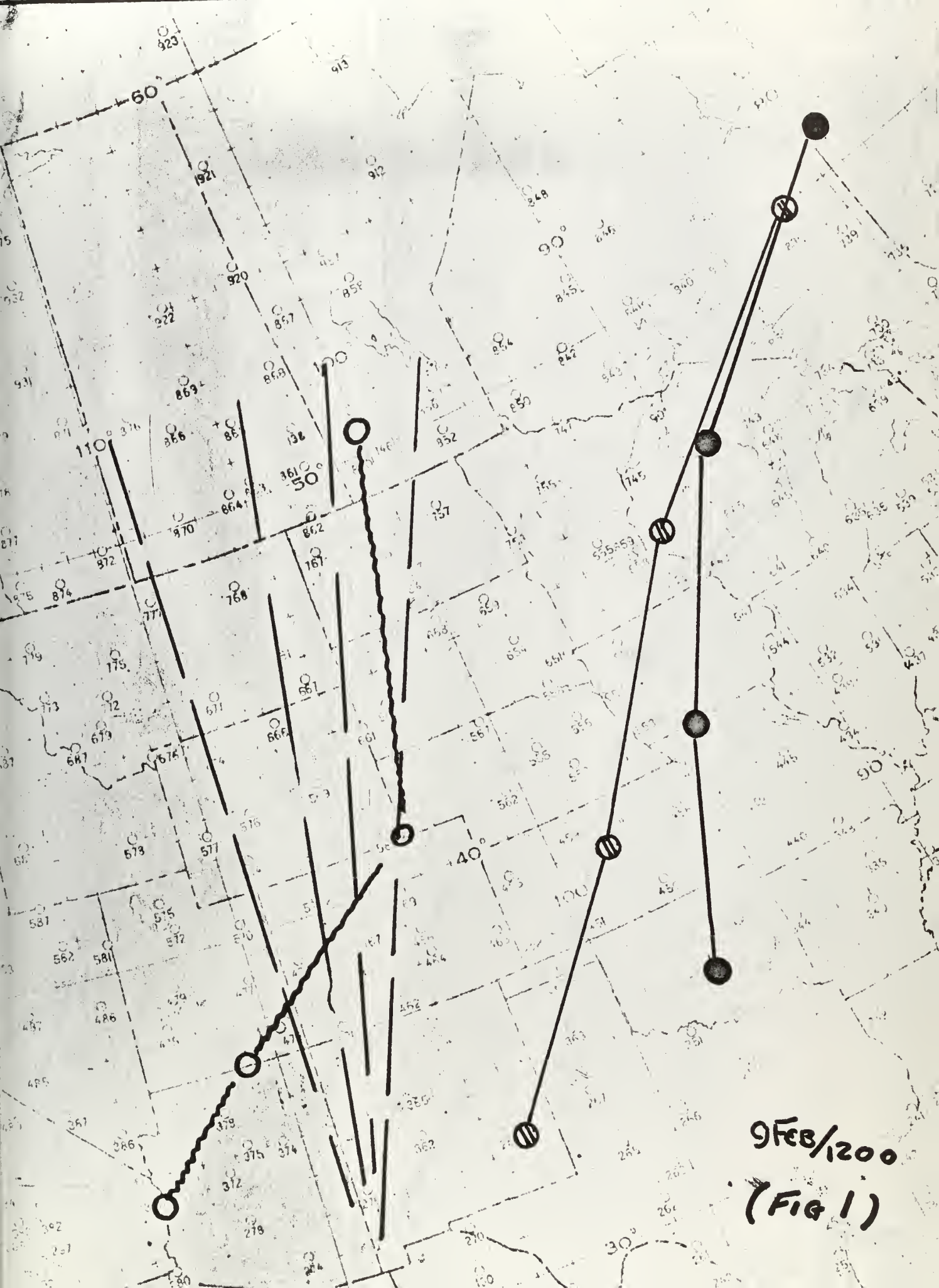
 500-mb SD 48-hour prognosis

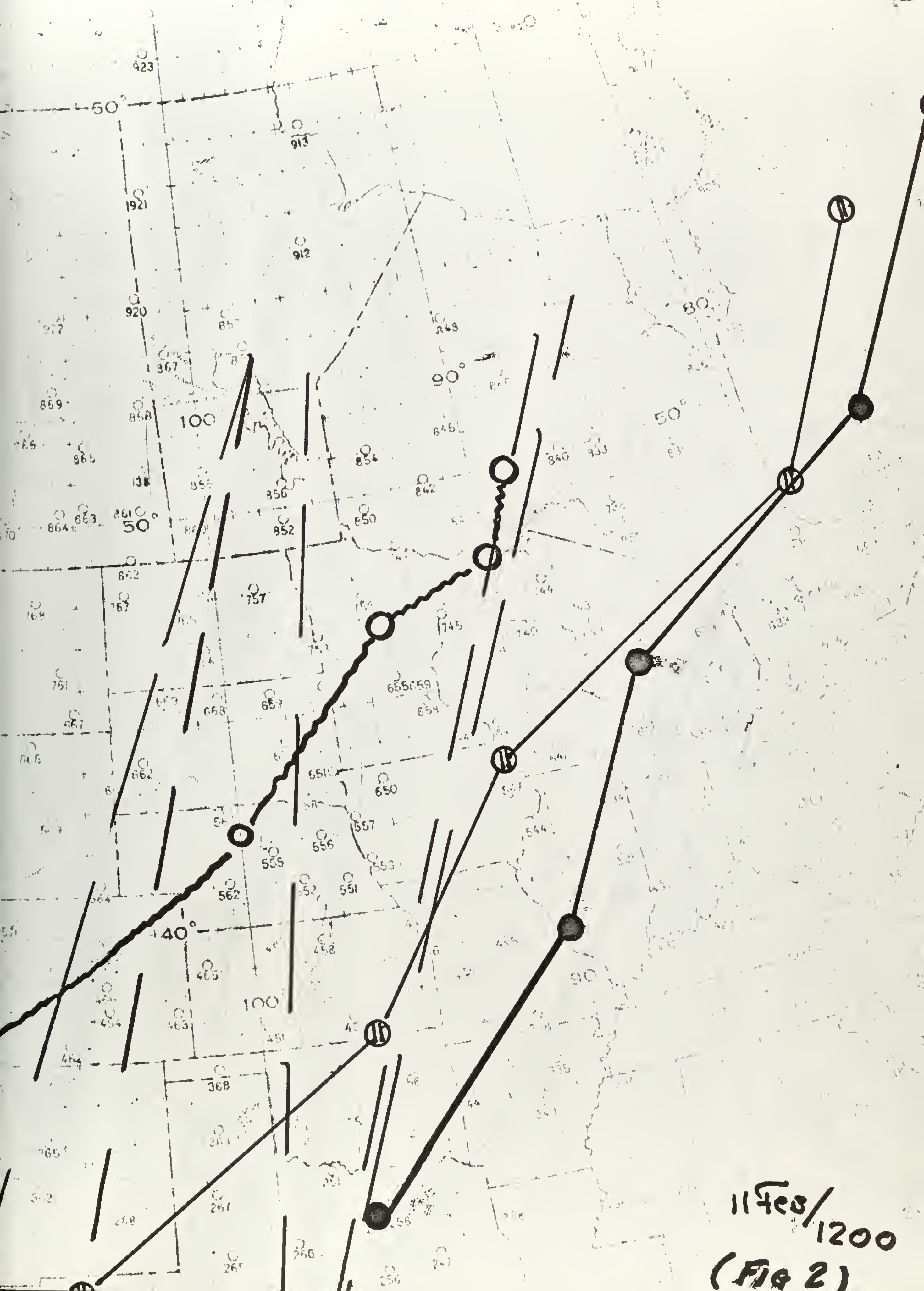
 500-mb SD 24-hour prognosis

 500-mb SD analysis trough

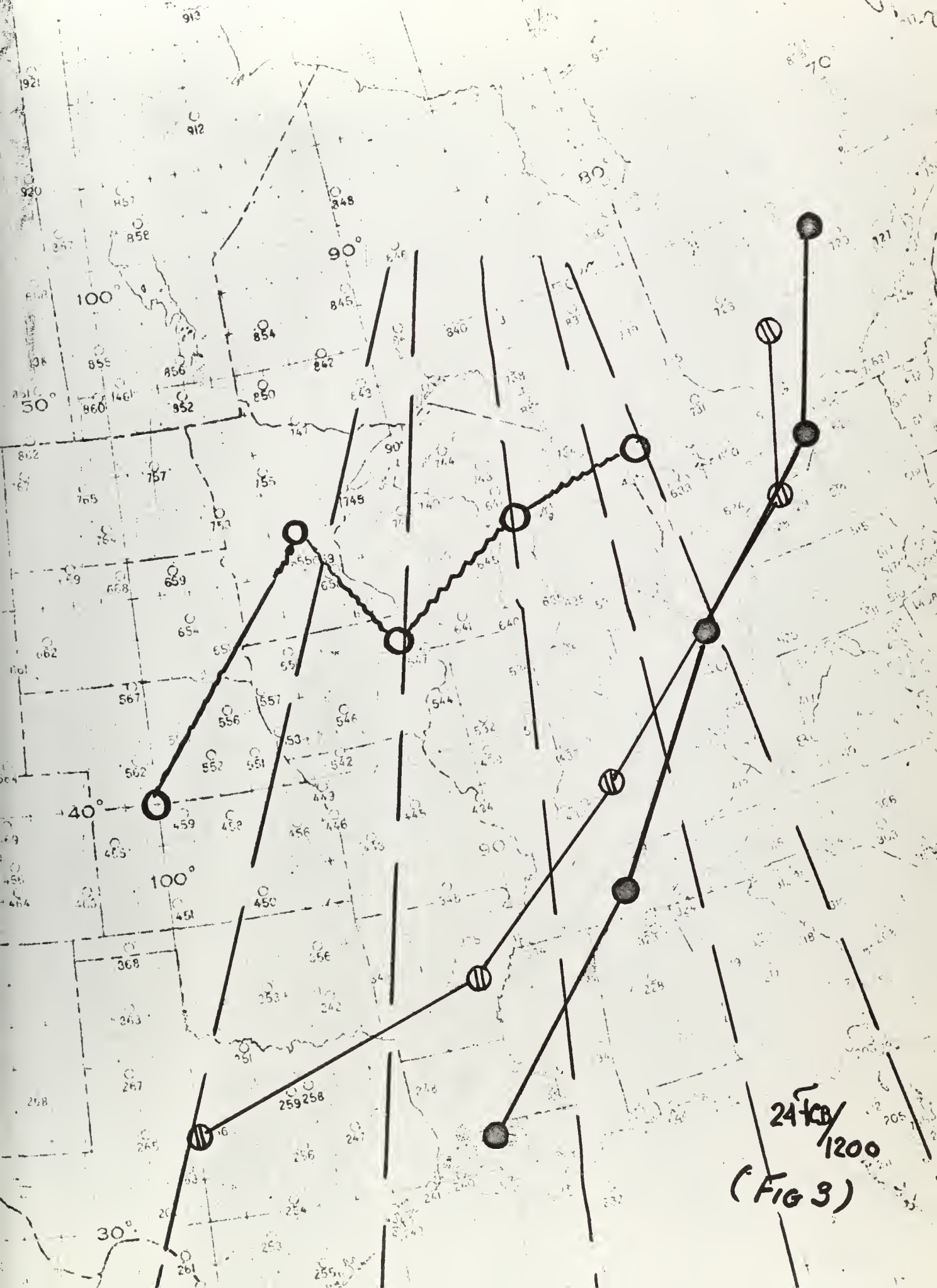
Tr Trough

Stat Stationary

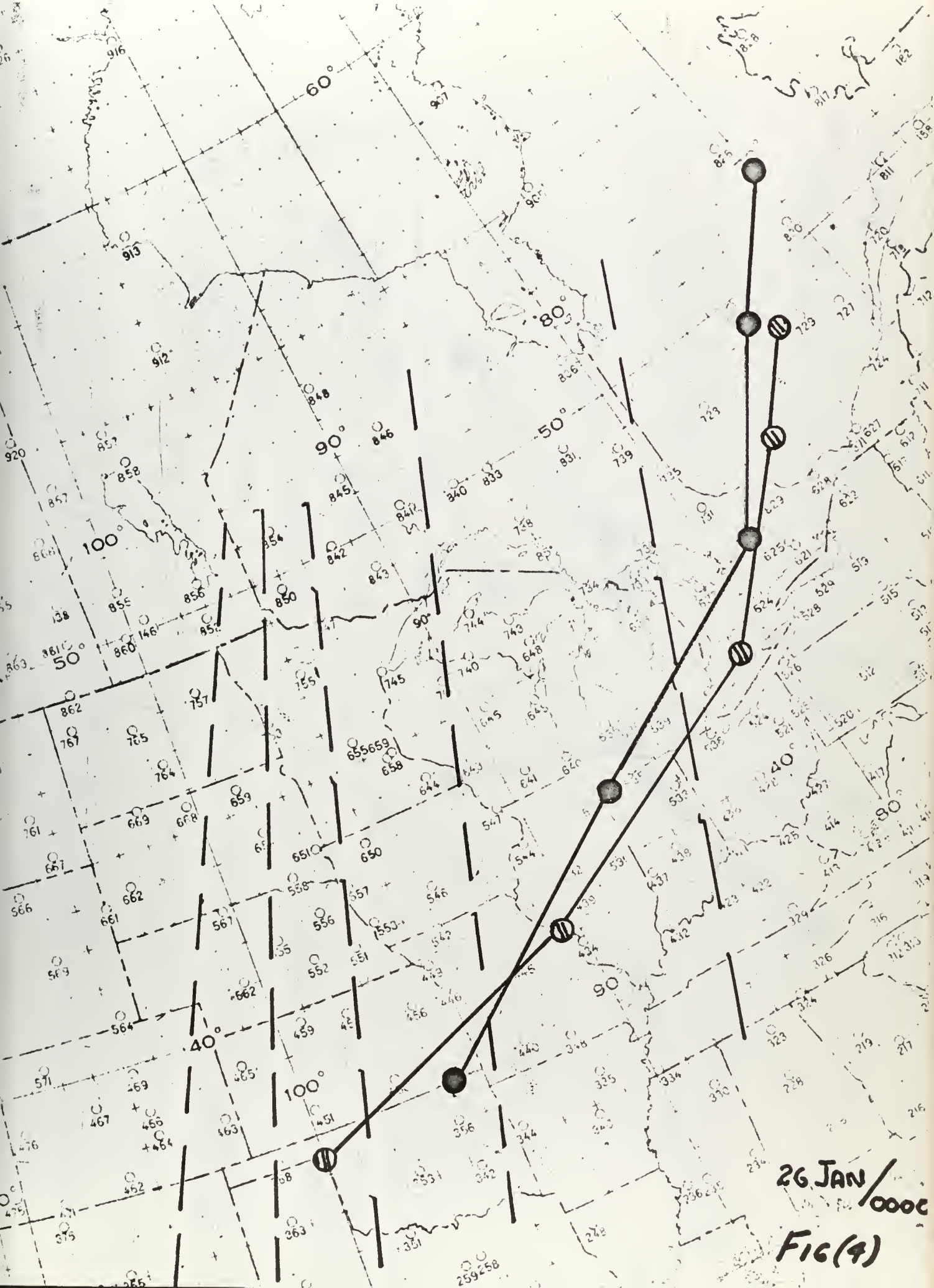

9FEB/1200
(FIG 1)

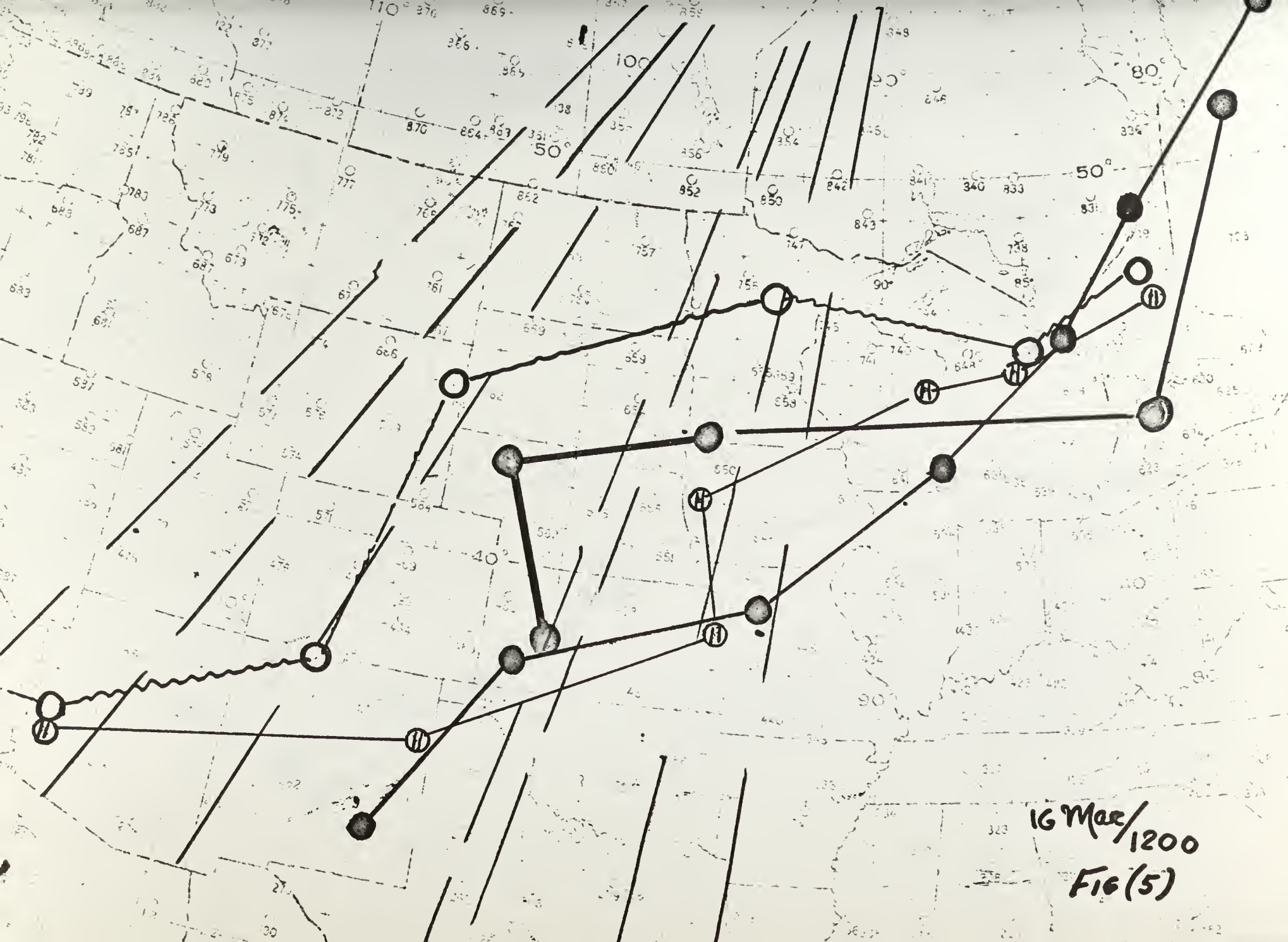


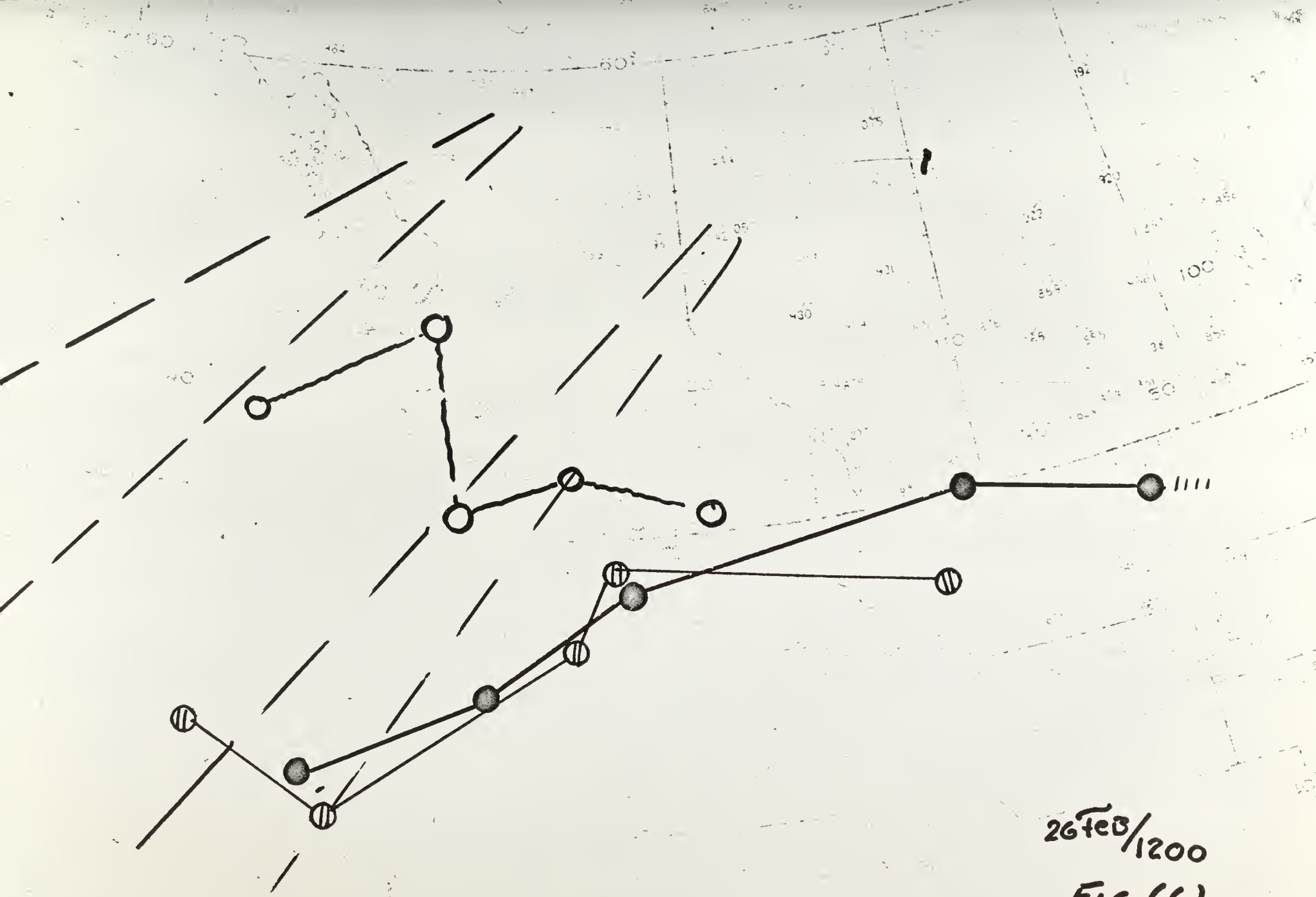
11 Feb/1200
(Fig 2)



(FIG 3)

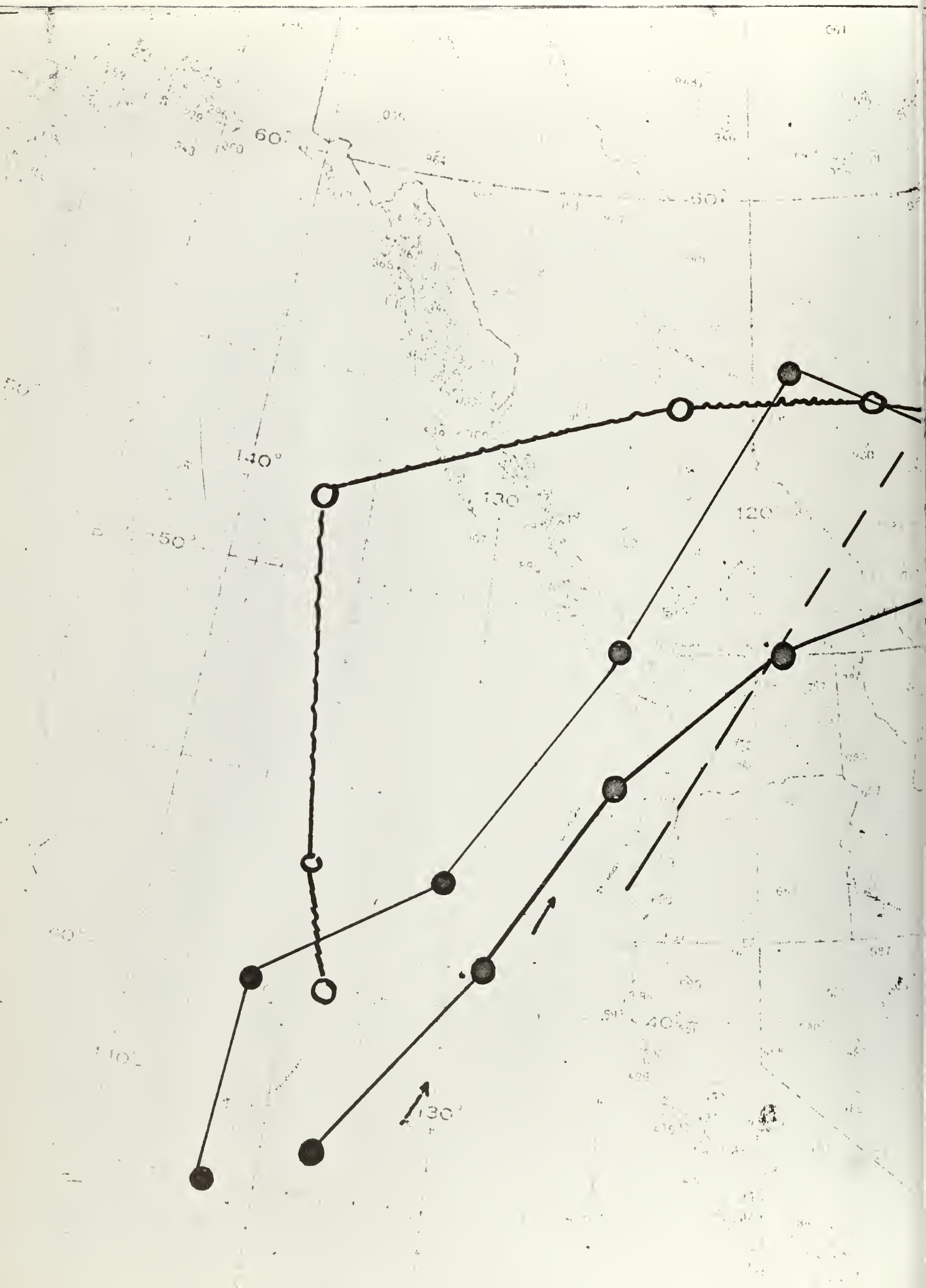

26 JAN/000
FIG(4)

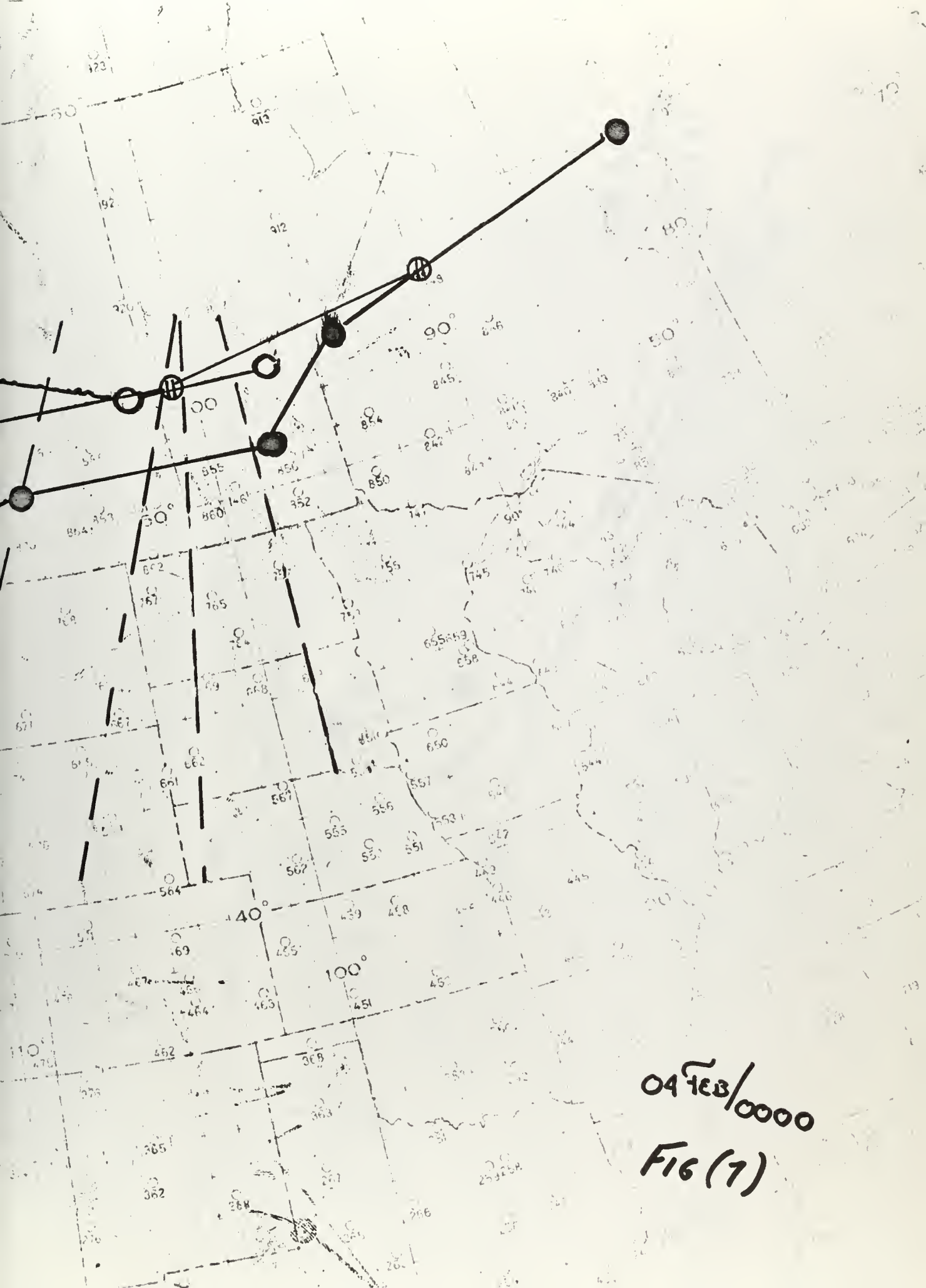

16 Mar/1200
Fig(5)



26 FEB/1200

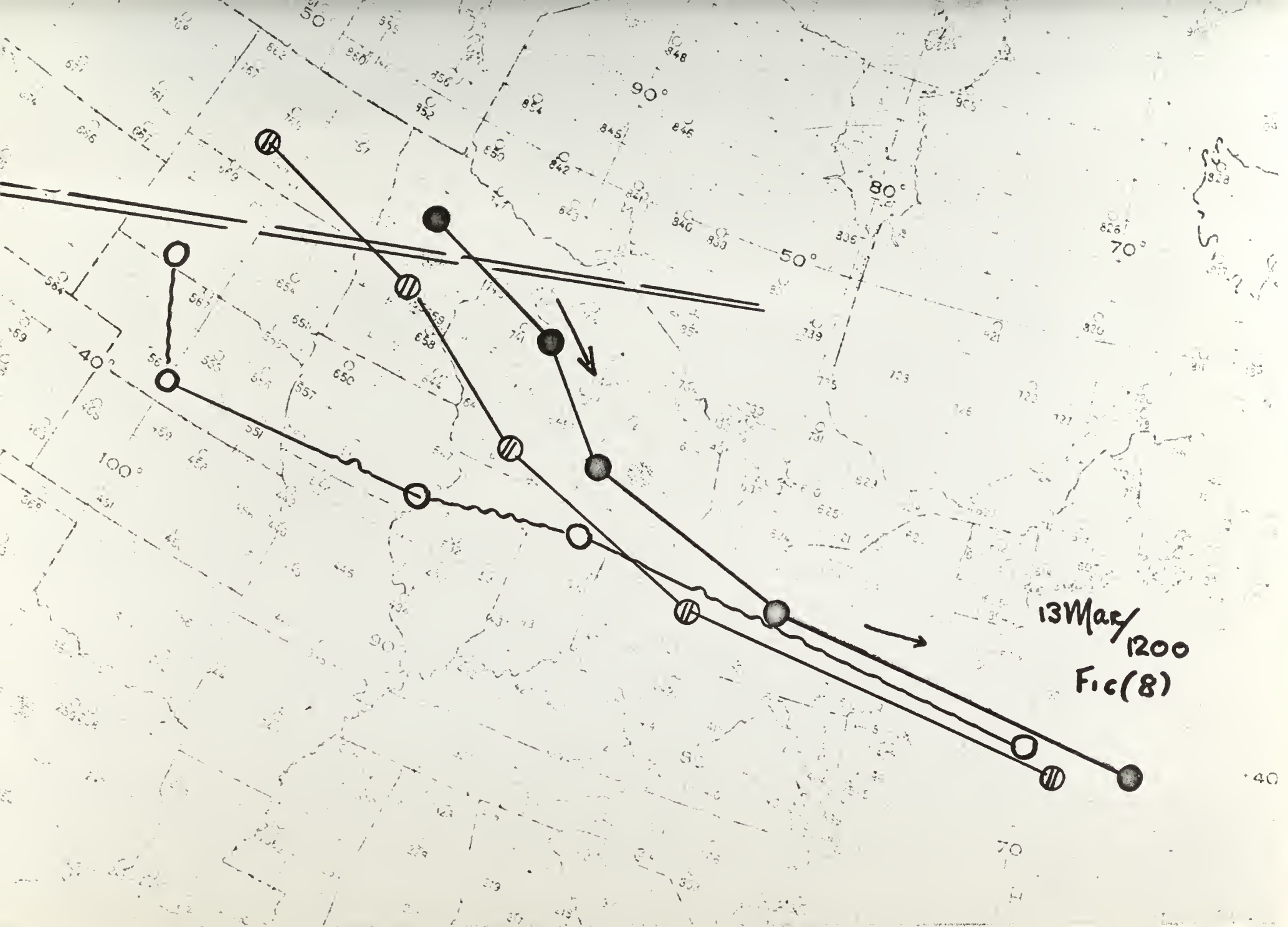
FIG (6)


60°
50°
140°
130
120
50°
40°
130°



04 FEB/0000

FIG (7)


13 Mar/1200
Fig(8)

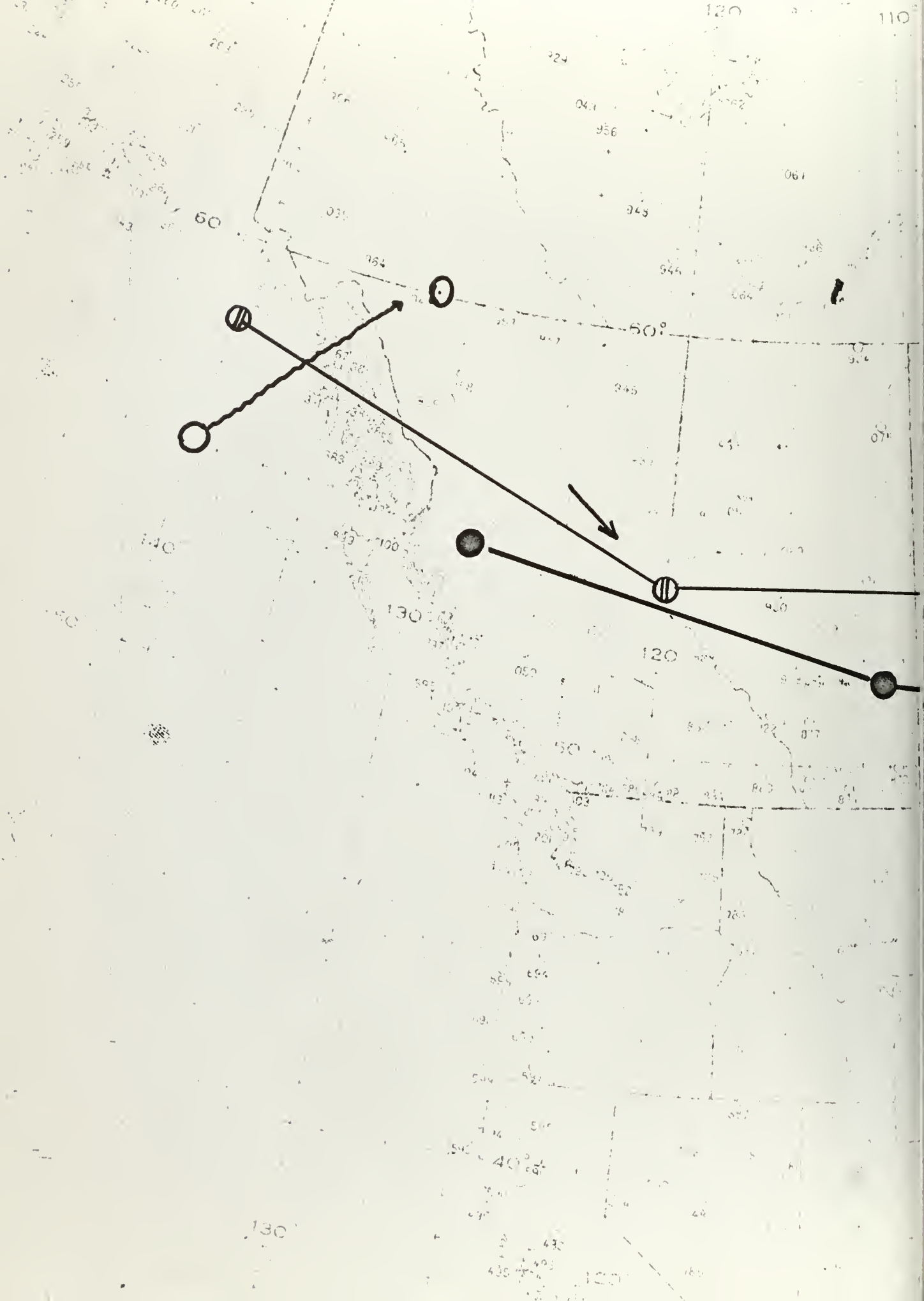
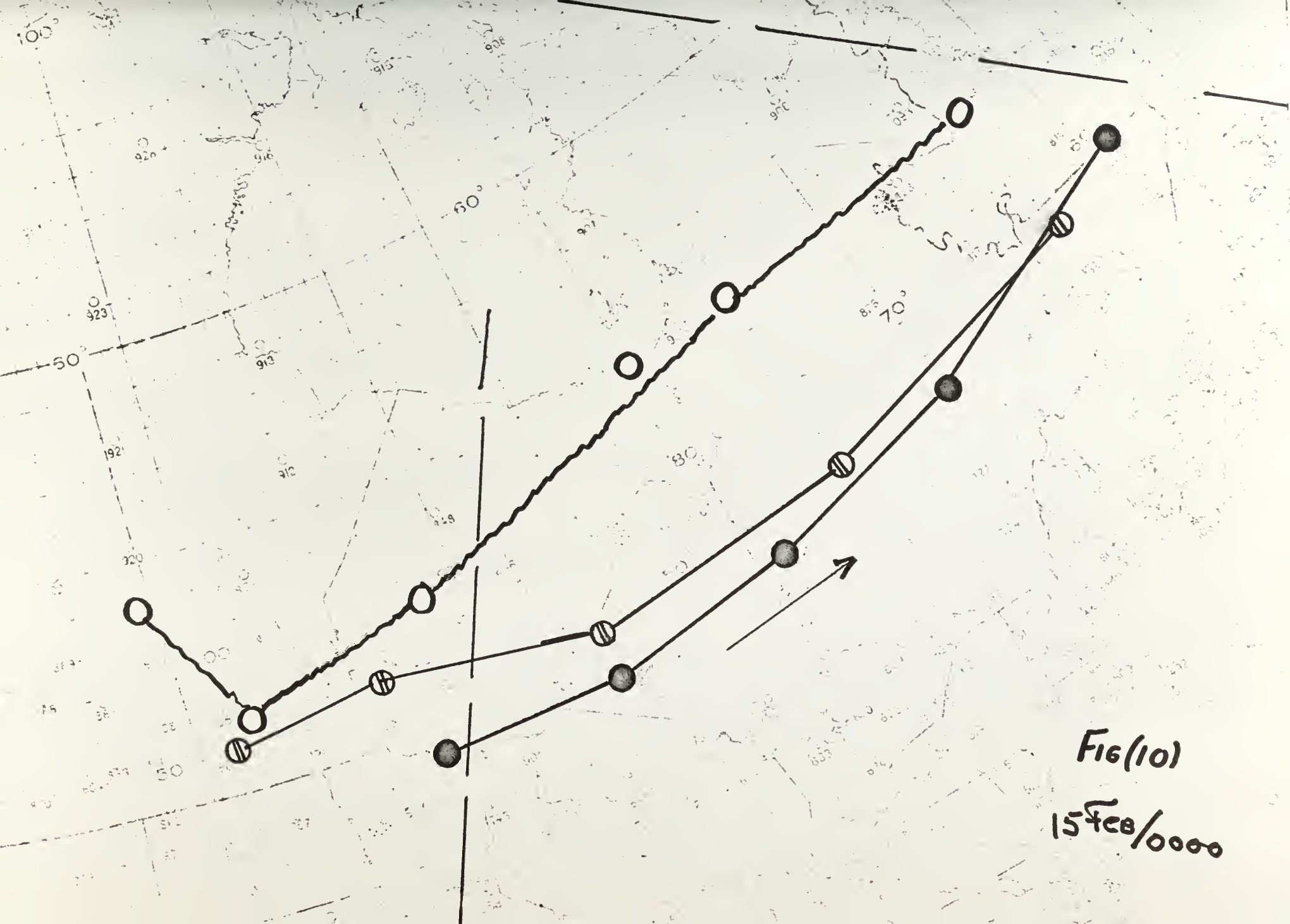


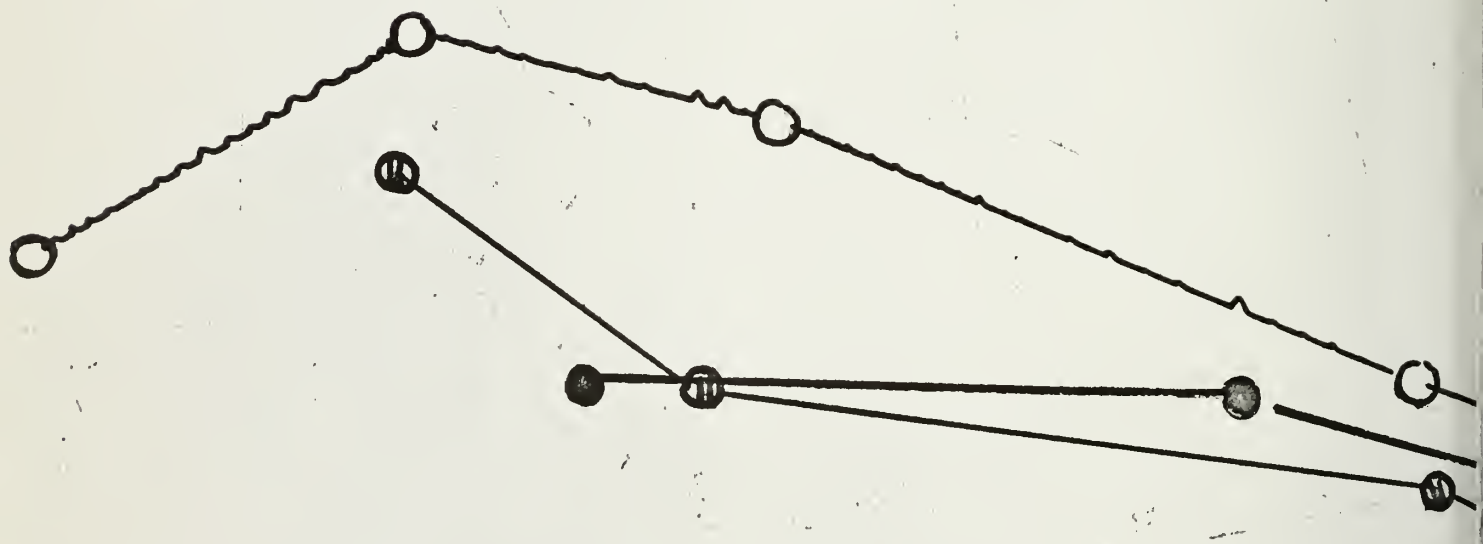
FIG (9)

19 FEB/1200



Fig(10)

15th Feb/0000



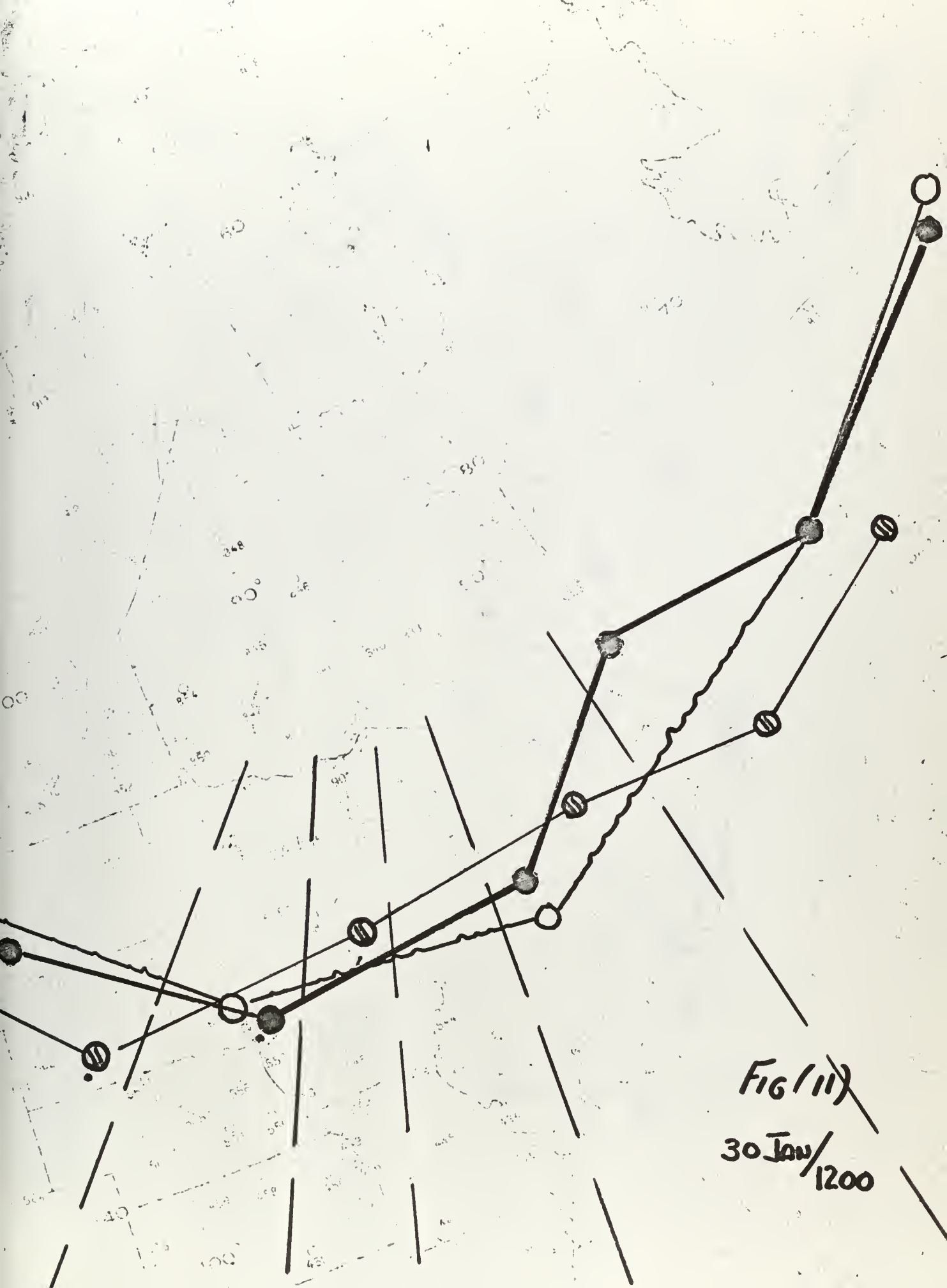


FIG (11)

30 Jan/1200

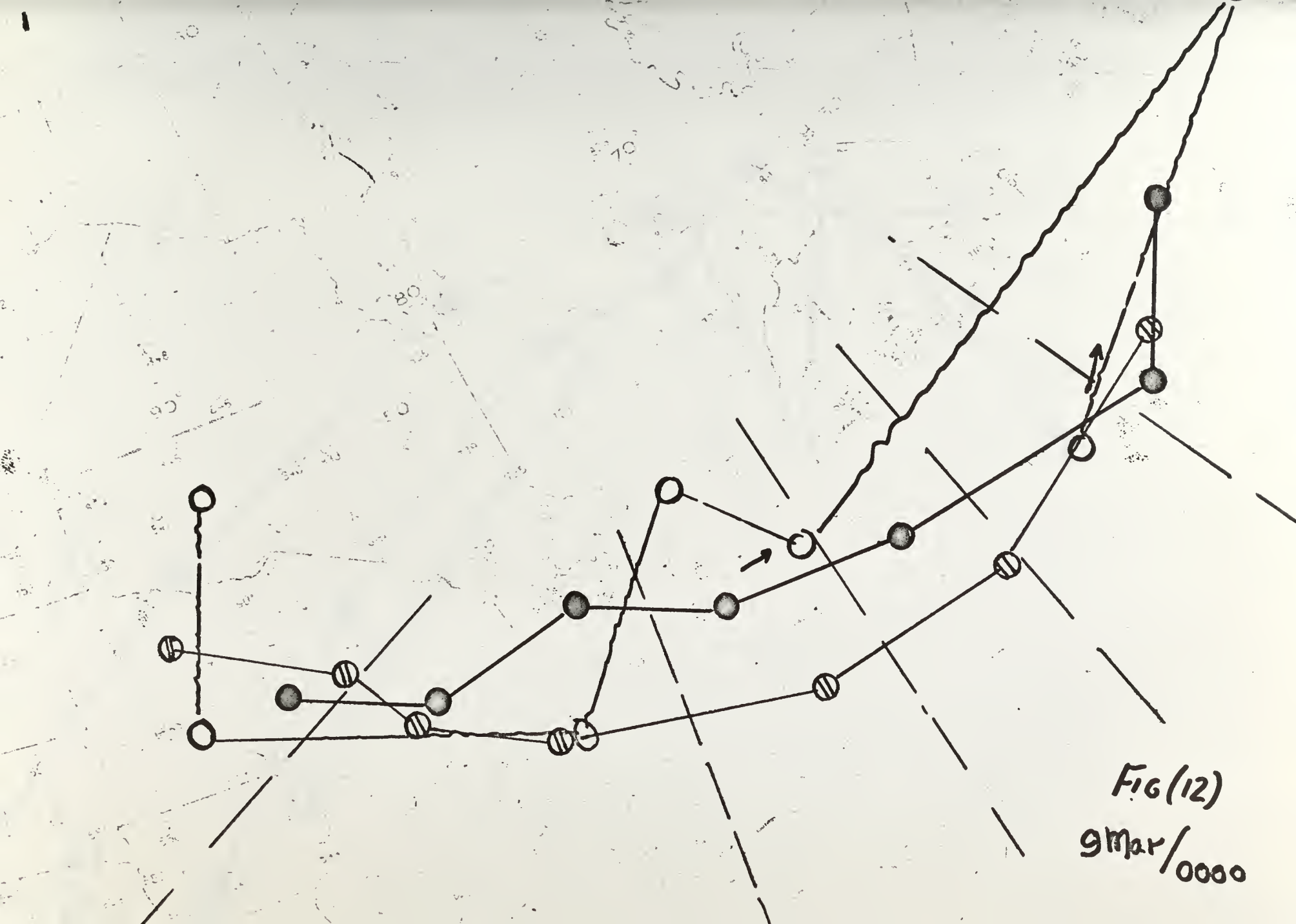
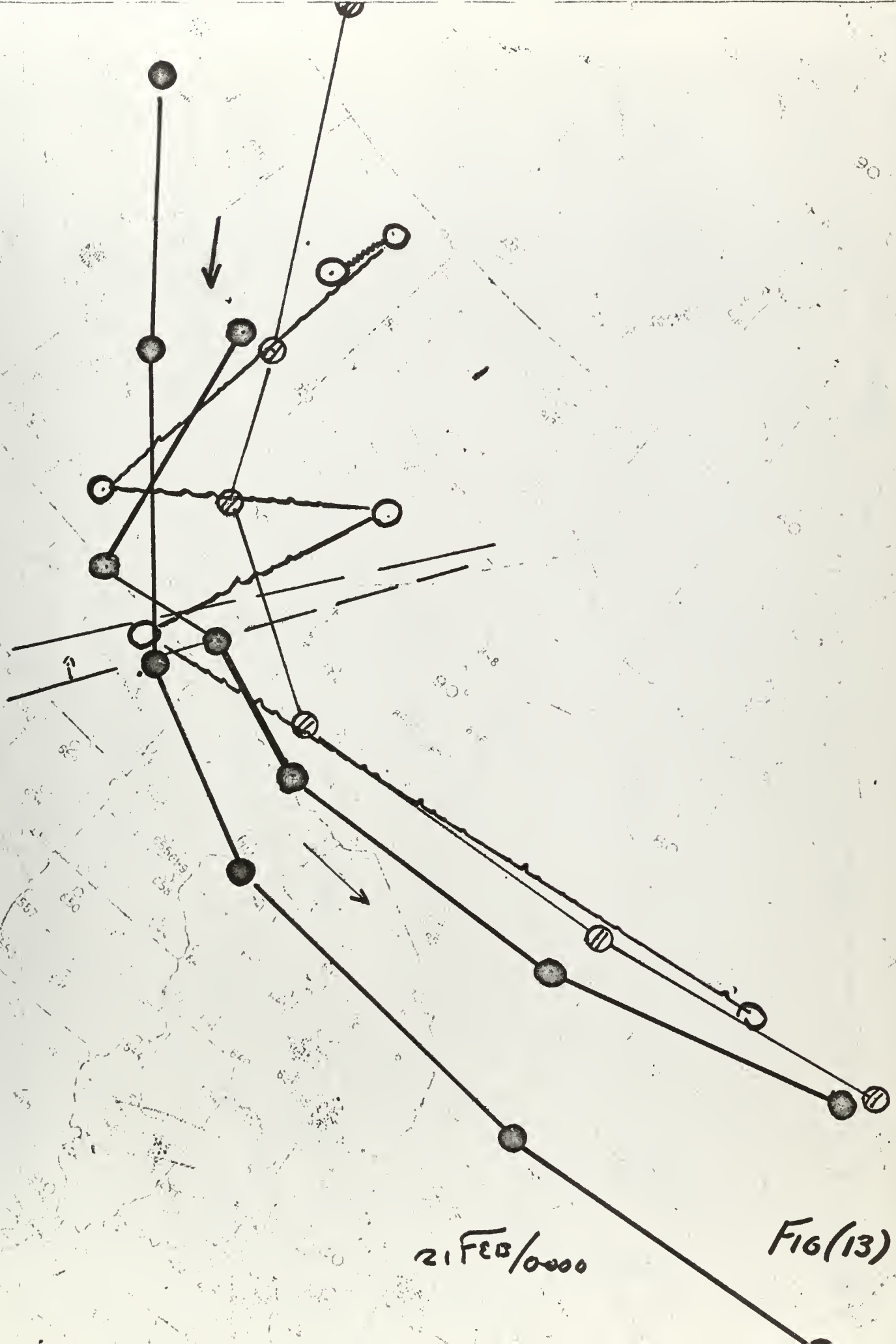


Fig (12)
9 Mar / 0000



21 FEB/0000

FIG(13)

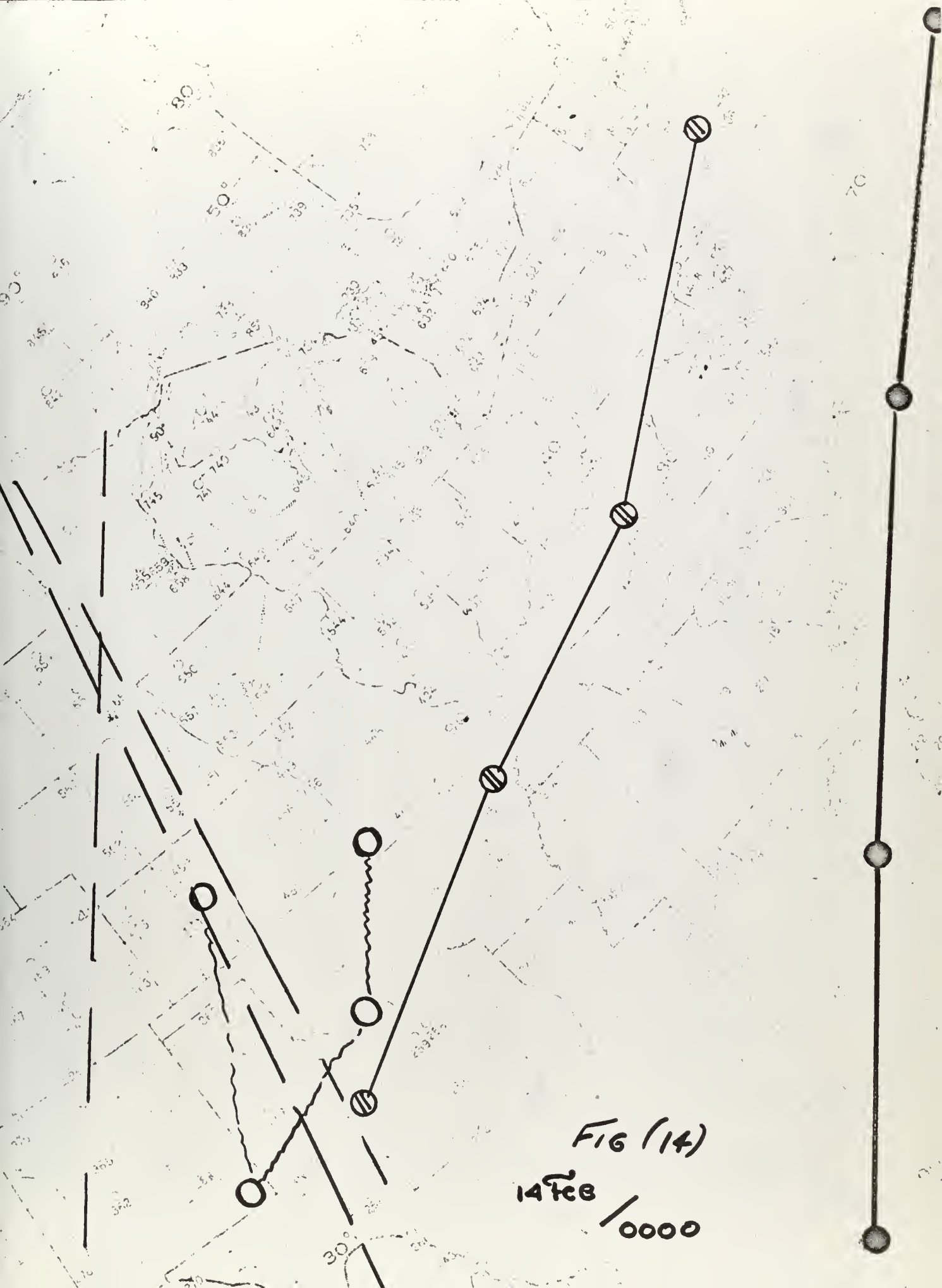
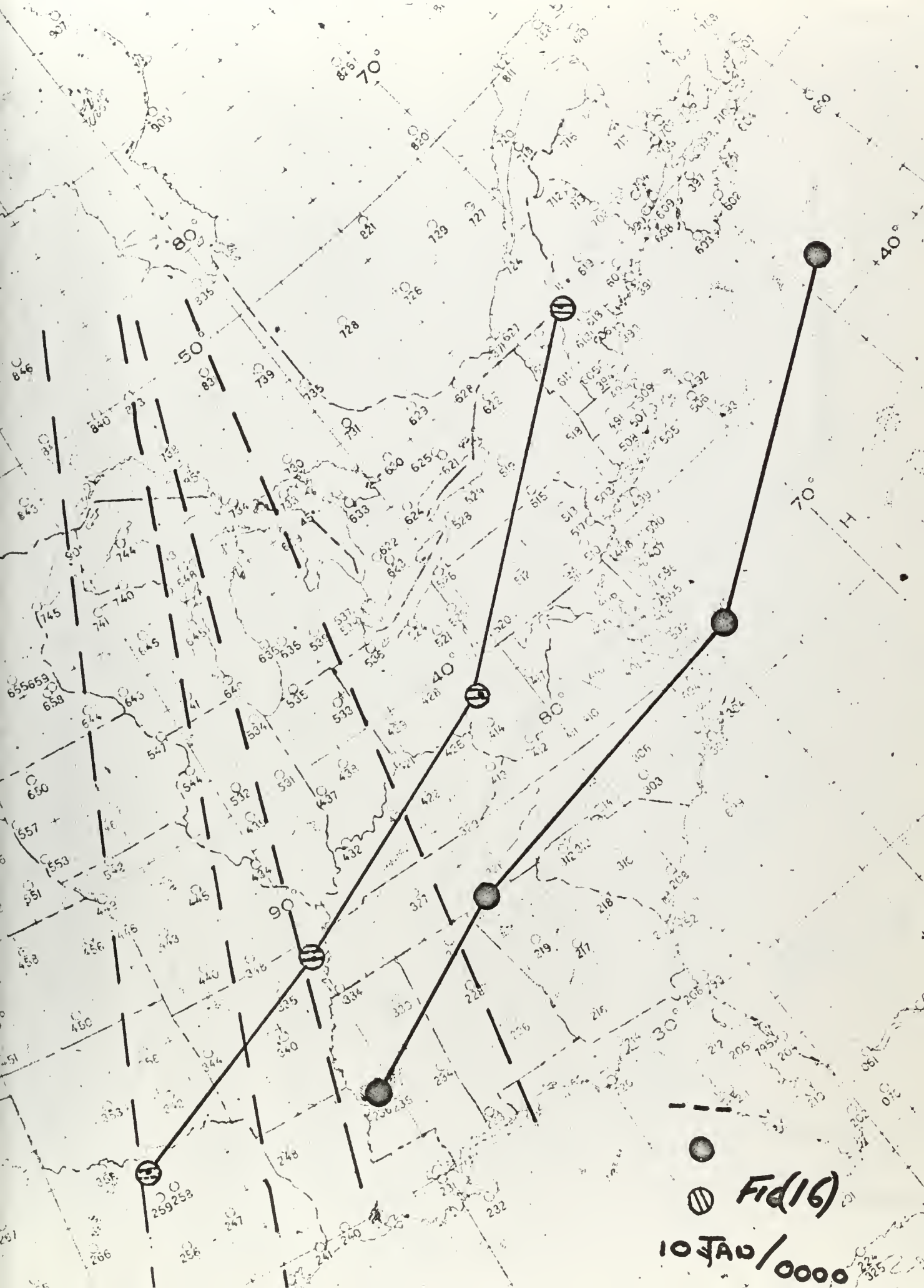
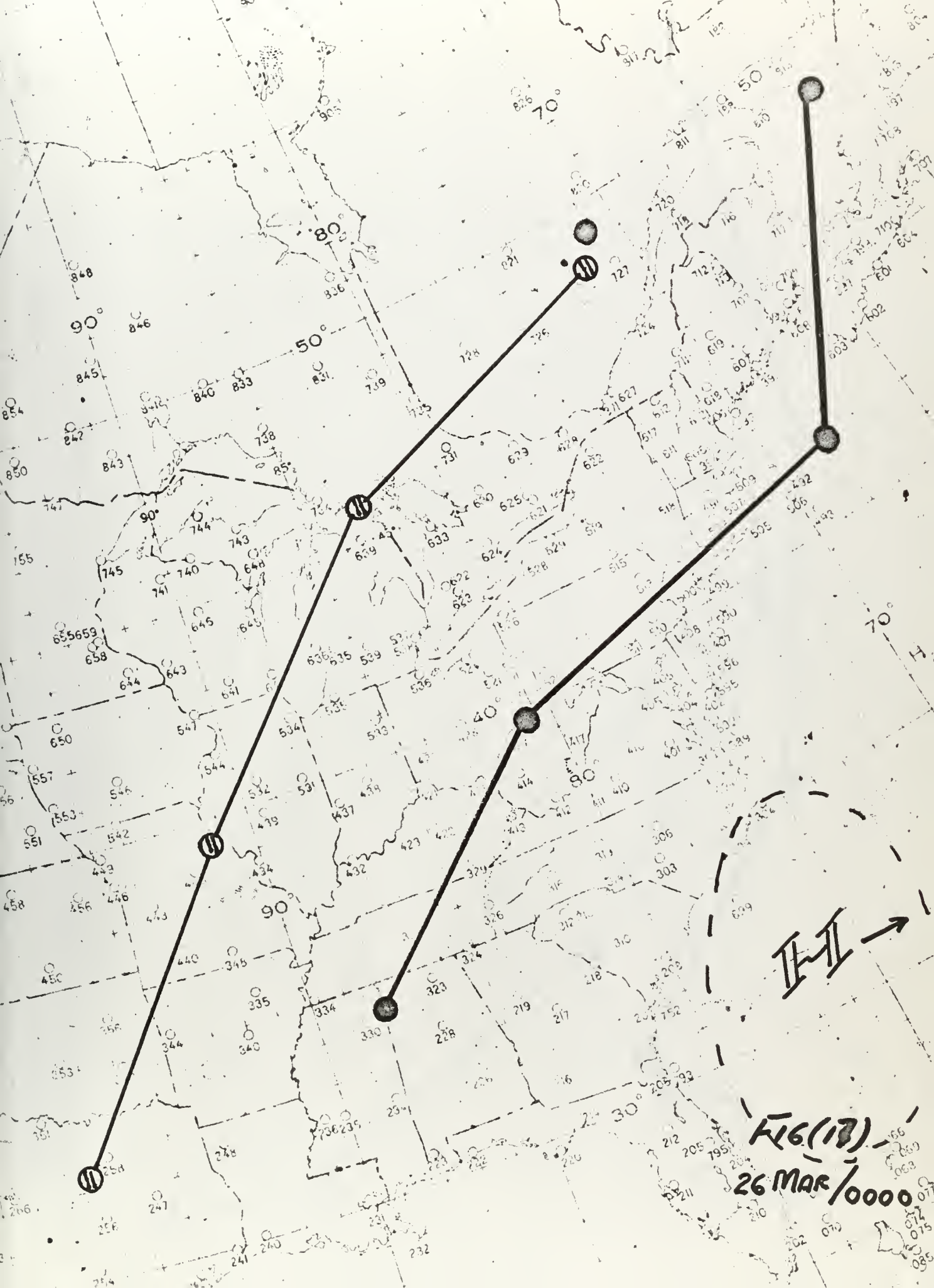


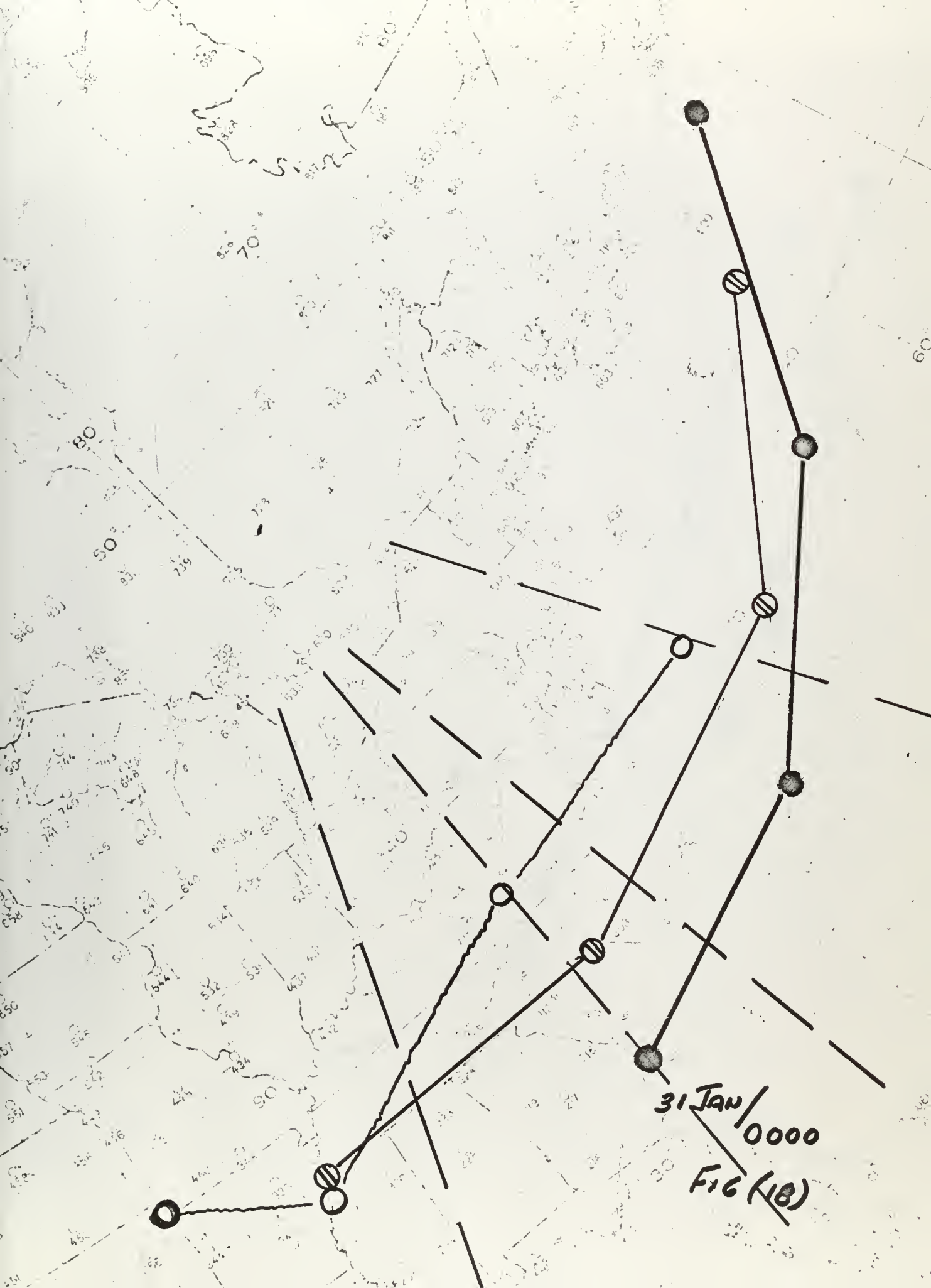
FIG (14)

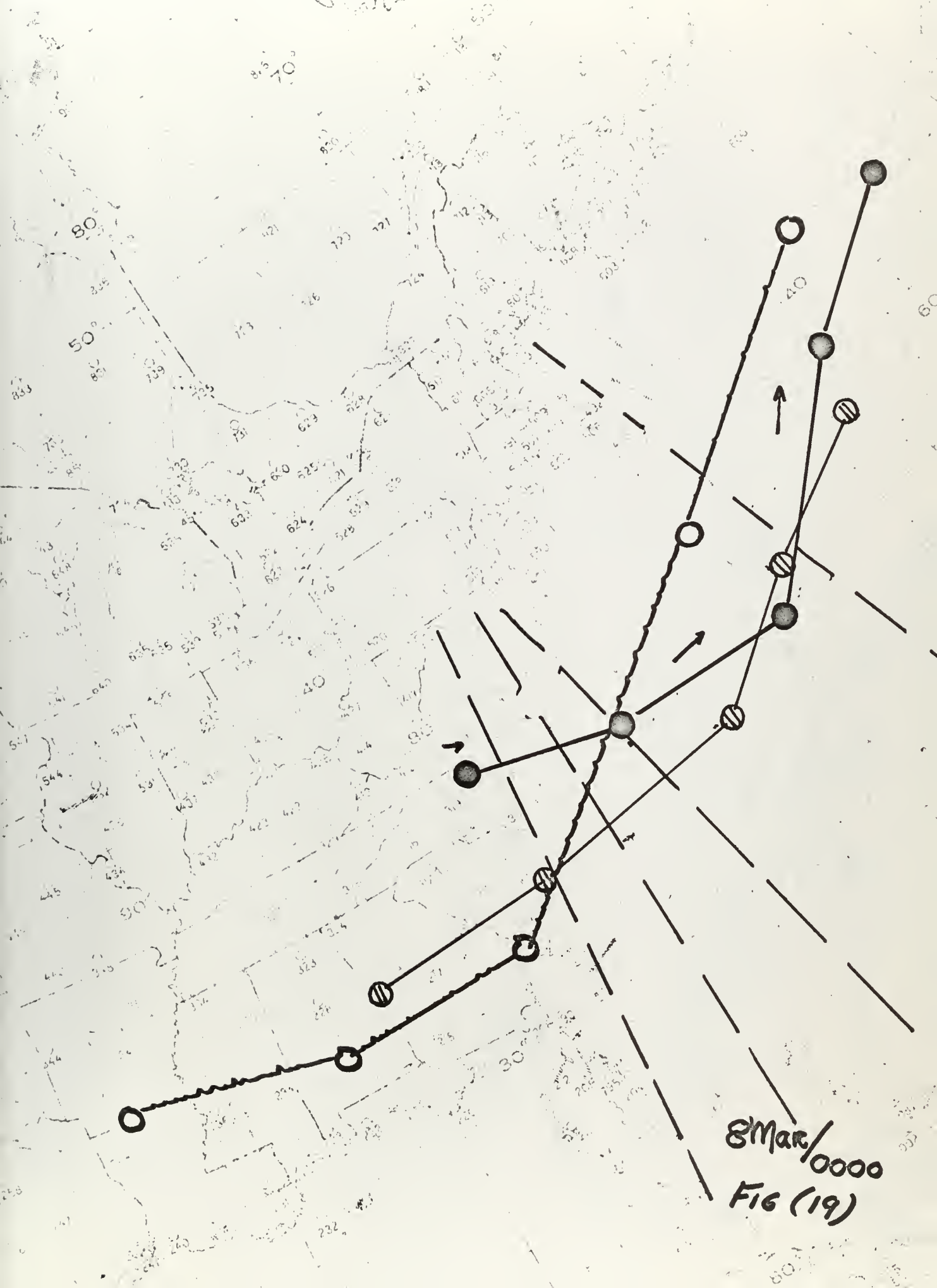
14 FEB /0000

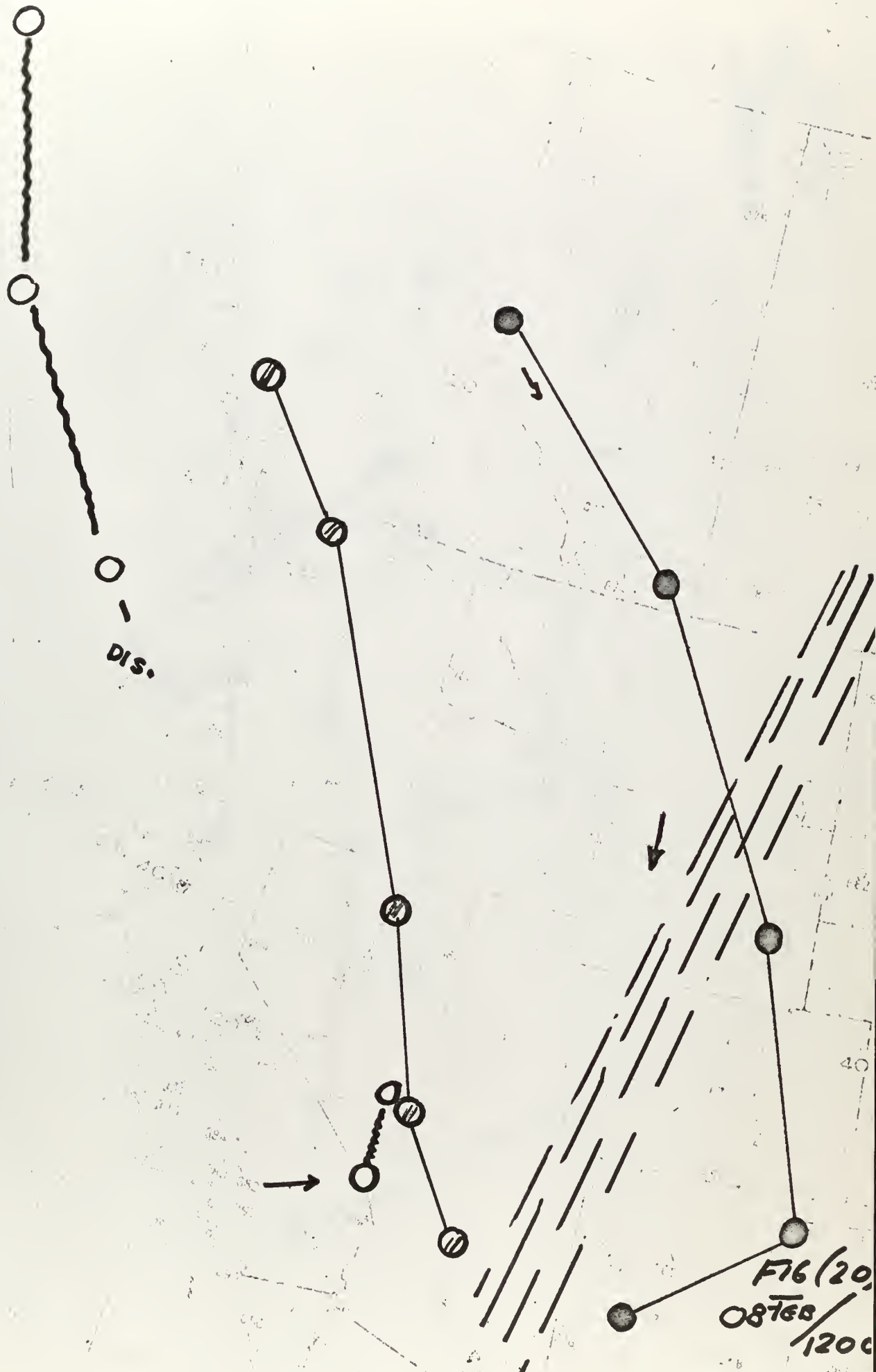
FIG(15)
20 Mar/0000

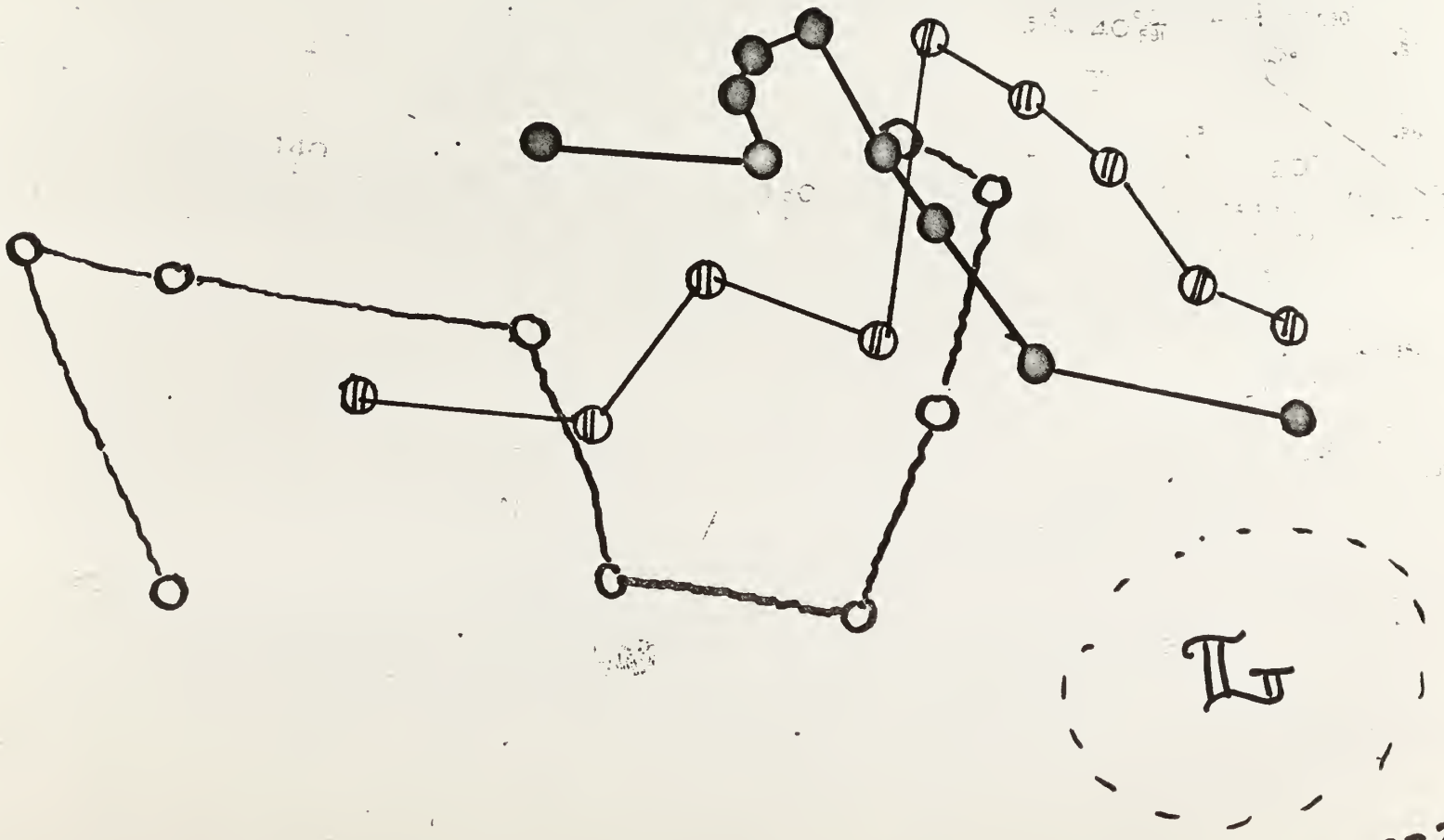

Fig(16)
10 JAN/0000


FIG(17)
26 MAR/0000


31 JAN / 0000
FIG (1B)


8 Mar/0000
FIG (19)


DIS.
FIG (20
08 FEB
/120



03 Mar/1200

FIG (21)